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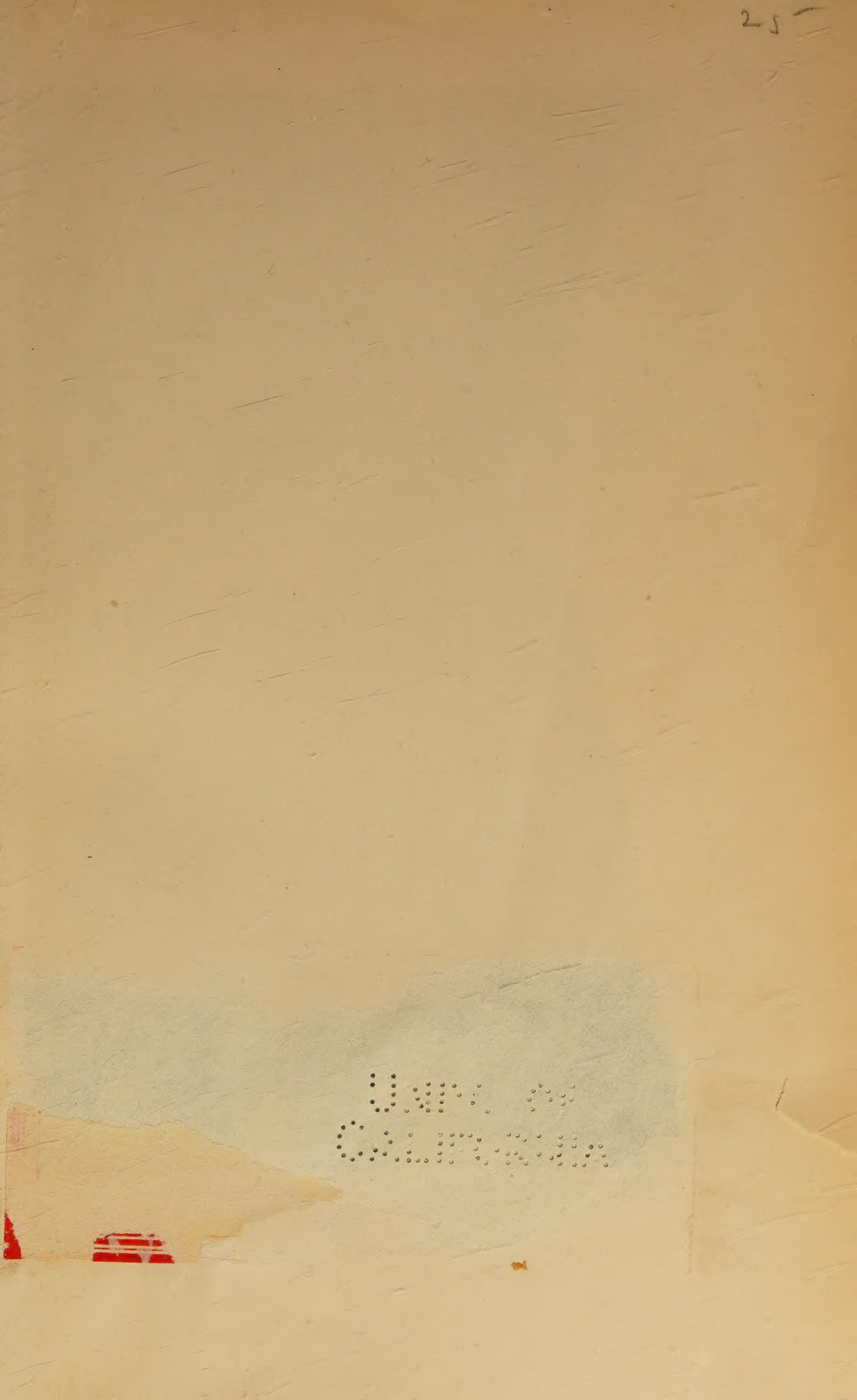

Looking up Brush Creek near DeBeque, Colorado, showing oil shale strata.

SHALE OIL

BY

RALPH H. McKEE, PH.D., LL.D.

AND

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American Chemical Society
Monograph Series

BOOK DEPARTMENT
The CHEMICAL CATALOG COMPANY, *Inc.*
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GENERAL INTRODUCTION

American Chemical Society Series of Scientific and Technologic Monographs

By arrangement with the Interallied Conference of Pure and Applied Chemistry, which met in London and Brussels in July, 1919, the American Chemical Society was to undertake the production and publication of Scientific and Technologic Monographs on chemical subjects. At the same time it was agreed that the National Research Council, in coöperation with the American Chemical Society and the American Physical Society, should undertake the production and publication of Critical Tables of Chemical and Physical Constants. The American Chemical Society and the National Research Council mutually agreed to care for these two fields of chemical development. The American Chemical Society named as Trustees, to make the necessary arrangements for the publication of the monographs, Charles L. Parsons, Secretary of the American Chemical Society, Washington, D. C.; John E. Teeple, Treasurer of the American Chemical Society, New York City; and Professor Gellert Alleman of Swarthmore College. The Trustees have arranged for the publication of the American Chemical Society series of (a) Scientific and (b) Technologic Monographs by the Chemical Catalog Company of New York City.

The Council, acting through the Committee on National Policy of the American Chemical Society, appointed the editors, named at the close of this introduction, to have charge of securing authors, and of considering critically the manuscripts prepared. The editors of each series will endeavor to select topics which are of current interest and authors who are recognized as authorities in their respective fields. The list of monographs thus far secured appears in the publisher's own announcement elsewhere in this volume.

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The development of knowledge in all branches of science, and especially in chemistry, has been so rapid during the last fifty years and the fields covered by this development have been so varied that it is difficult for any individual to keep in touch with the progress in branches of science outside his own specialty. In spite of the facilities for the examination of the literature given by Chemical Abstracts and such compendia as Beilstein's Handbuch der Organischen Chemie, Richter's Lexikon, Ostwald's Lehrbuch der Allgemeinen Chemie, Abegg's and Gmelin-Kraut's Handbuch der Anorganischen Chemie and the English and French Dictionaries of Chemistry, it often takes a great deal of time to coördinate the knowledge available upon a single topic. Consequently when men who have spent years in the study of important subjects are willing to coördinate their knowledge and present it in concise, readable form, they perform a service of the highest value to their fellow chemists.

It was with a clear recognition of the usefulness of reviews of this character that a Committee of the American Chemical Society recommended the publication of the two series of monographs under the auspices of the Society.

Two rather distinct purposes are to be served by these monographs. The first purpose, whose fulfilment will probably render to chemists in general the most important service, is to present the knowledge available upon the chosen topic in a readable form, intelligible to those whose activities may be along a wholly different line. Many chemists fail to realize how closely their investigations may be connected with other work which on the surface appears far afield from their own. These monographs will enable such men to form closer contact with the work of chemists in other lines of research. The second purpose is to promote research in the branch of science covered by the monograph, by furnishing a well digested survey of the progress already made in that field and by pointing out directions in which investigation needs to be extended. To facilitate the attainment of this purpose, it is intended to include extended references to the literature, which will enable anyone interested to follow up the subject in more detail. If the literature is so voluminous that a complete bibliography is impracticable, a critical selection will be made of those papers which are most important.

The publication of these books marks a distinct departure in the policy of the American Chemical Society inasmuch as it is a serious attempt to found an American chemical literature without primary regard to commercial considerations. The success of the venture will depend in large part upon the measure of coöperation which can be secured in the preparation of books dealing adequately with topics of general interest; it is earnestly hoped, therefore, that every member of the various organizations in the chemical and allied industries will recognize the importance of the enterprise and take sufficient interest to justify it.

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PREFACE

Civilization and the progress of man have always depended upon the production of heat and energy. Before man there was no knowledge of the uses of heat and indeed it is only in the latter periods of man's evolution that such uses began to be developed. To the development and uses of the fuel resources of the world we owe our present civilization and, directly or indirectly, practically every useful work known to man.

The most concentrated and the most easily used fuels have been those most sought for and most used. The discovery of a new and more concentrated fuel has been followed each time by a notable increase in the number and importance of devices for the conversion of heat into other forms of energy valuable to industry and life.

This volume has been written because petroleum has achieved such great importance as a concentrated fuel in American industrial life and because oil from oil shale promises in the immediate future to supplement the supplies of well petroleum, and, in the more distant future, when the supply of well petroleum gradually fails, to furnish the bulk of the oil needed.

In this volume we have attempted to bring together such information as will give the reader a true and correct view of the shale oil situation and, even more important, to furnish to the worker in this field a knowledge of what has been recorded in the printed word relative to shale oil. With this last in view the abstracts of articles relating to shale oil have been made quite full and so far as possible none of importance has been omitted. It would be too much to hope that we have been successful in this effort and accordingly we would be pleased to be notified of any important published articles in this field which have been overlooked.

The late Dr. David T. Day kindly made available his collection of (1781-1917) patents in this field. This collection formed the basis of Chapter 12 and we wish to here express our appreciation of this aid.

In Chapter 11 we have in many cases made use of the excellent résumés published in *Chemical Abstracts* by the American Chemical Society. To Dr. Crane, the editor of *Chemical Abstracts,* we wish to express our thanks for permission to use these abstracts.

Help and courtesies have been received from many other than those whose names appear in this Table of Contents. In particular we wish to mention and to thank Miss Margaret J. Stone, Mr. Myron W. Colony, Mr. Paul D. V. Manning and Mr. John C. Stauffer for the aid which they have given.

RALPH H. MCKEE.

Columbia University,
New York City.
April 24, 1925.

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SHALE OIL

CHAPTER 1

SHALE OIL, A GENERAL VIEW OF THE INDUSTRY

By Ralph H. McKee

Since man first began to use stored energy he has been dependent for fuels upon products stored away by nature many centuries ago. Such a supply will not last forever, but a perusal of the history of man's fuel and energy supply, with its continued introduction of new types and sources of fuel before the older ones have given out, makes one believe—a belief perhaps engendered by hope—that by the time our natural fuel resources are exhausted we may have found ways to utilize the energy of the sunshine, the tides, and the waves.

With the gradual exhaustion of the easily obtained concentrated fuels, future progress of civilization demands that we look ahead to the prospect of the employment of those fuel resources which are more difficult to prepare in a concentrated form from their natural diffused form.

In the history of man we have passed from the era of the non-use of fuels to that of the development of concentrated fuels. Ahead of us lies the era of the use of the less concentrated fuels.

The present most important fuels are those which can most conveniently be produced and used. These are generally those most concentrated in form. Early man had as fuel small branches of trees ("fagots"), later he used larger wood, and the series continues with the use of wood charcoal, bituminous coal, anthracite, and cokes of various kinds. In the gas fuels the series may be said to be gas from wood, gas from rosin, gas from cannel coal, gas from bituminous coal, natural gas, and gas from cracking of oils.

In the liquid fuels we have the early use of vegetable oils like olive oil, followed by fish and animal oils, oils from cannel coals, and oils from oil shale. Finally, we see the world's supply of petroleum rapidly being exhausted. With appreciation of the fact that the petroleum supply

is exhaustible comes the demand that technologists open up new fields of petroleum or find or make other oils which can be used in place of the petroleum products whose virtues have become well recognized only during the last two decades.

At this point it may be worth recalling to the American reader that the word "petroleum" was used for shale oil and similar rock oils long before the drilling of the first petroleum well (1859). Indeed, the word was in use in England for such an oil at least as early as the middle of the 14th century.

Of the possible products which can be used to supplement the supply of petroleum, oil from oil shale has the greatest promise, first, because of all the suggested new materials it alone gives products which the user can hardly, if at all, distinguish from the similar products made from well petroleum, and second, because shale oil is produced from the only raw material (oil shale) which is sufficiently abundant to supply the anticipated need for oil. Alcohol has been suggested as a motor fuel, but the supply of alcohol is not, and practically cannot be made sufficient to meet an appreciable part of the demand for motor fuel. If all the alcohol made in this country in a year was used as motor fuel, it would be able to supply almost exactly the fuel used by the automobiles of this country on a single July Sunday.

True oil shale is a clayey or sandy deposit from which petroleum may be obtained by distillation but not by treatment with solvents. Tar sands or sand deposits which are saturated with oil or asphalt and from which the oily constituents can be removed by solvents are not considered true oil shales.

The great size of the oil shale deposits of the United States is not generally appreciated. The United States has furnished and is furnishing about two-thirds of the world's supply of petroleum. Since the discovery of oil in Pennsylvania in 1859, about eight billion barrels of oil have been taken from the petroleum wells of the United States. The oil shales of the Green River formation in Colorado and Utah alone can furnish fifteen times this amount of oil. If we add to this the oil reserves in the form of oil shales in other states we have a total potential shale-oil supply greater by twenty times than the total oil that the oil wells of this country have yielded in the past sixty years, and this without considering shales which produce less than 30 gallons of oil per ton.

Oil shale deposits are in no sense limited to America: almost every country of the globe has similar, though not such extensive, deposits. In two of these countries, France and Scotland, oil has been made from oil shale for more than seventy years. The shale oil industries in these countries, though continuing to the present, have not been particularly

prosperous, owing to the severe competition of petroleum imported from America, Russia, and Roumania.*

These oil shale deposits vary among themselves, not only in yield of oil, character of oil, type and character of minor constituents, but also in the gangue material which carries the organic oil-yielding constituents. The shales whose commercial utilization can be expected to be started in the present decade vary in oil yield from fifteen to sixty gallons a ton. The character of shale oils varies as greatly as do the shales from which they are produced; some are highly asphaltic, somewhat like typical California crude petroleum; others have a paraffin content greater than that of the average Pennsylvania crude petroleum.

From petroleum no nitrogen compounds of value are obtained, but from oil shale ammonia and basic nitrogen compounds related to pyridine may be produced. Shales will yield ammonia (produced in the form of ammonium sulfate) in varying amounts up to sixty pounds per ton of shale and basic nitrogen compounds in amounts up to possibly fifty pounds per ton. Commercial yields from average shales will probably be about 33 per cent of these theoretical yields.

Sulfur is objectionable in an oil and is difficult to remove from it. America's largest oil shale deposits carry relatively little sulfur but some other deposits of importance yield high sulfur oils. One large oil shale bed in England yields an oil containing more than 6 per cent of sulfur—far too much to permit the oil to be refined by present known methods. Until a practical method of removing this sulfur has been devised, such high sulfur oils will probably be of little value.

Petroleum has found an ever increasing use and has now become an essential of modern civilization. Estimates of the United States Geological Survey and the United States Bureau of Mines indicate that the United States is approximately at the peak of its petroleum production, and that within a very few years the production of petroleum in the United States will begin to fall off. Moreover, the Geological Survey believes that the probability of discovering any more large fields of petroleum in the United States is remote, and therefore that petroleum production in the future can be calculated fairly closely.

On the other hand, the American consumption of petroleum is increasing yearly by more than fifty million gallons and since 1912 has normally been larger than the production. National power, increase of population and industry, and the development of modern types of civilization depend upon an adequate supply of energy. The most convenient and efficient form of energy now in use is that of petroleum, particularly in its application as a fuel for the internal combustion engine.

*For a detailed history and discussion of the Scottish and French shale oil industries see U. S. Bureau of Mines Bulletin 210 of 1924, cf. Abs. 1086.

The exhaustion of a natural resource is always deplorable, but the utilization leading to exhaustion often results in material gains which should not be overlooked. In a large measure the using up of American petroleum has been offset by the advances of industries and greater conveniences of modern life which it has made possible.

The relation of consumption to production of petroleum in the United States is shown graphically in Figure 1.

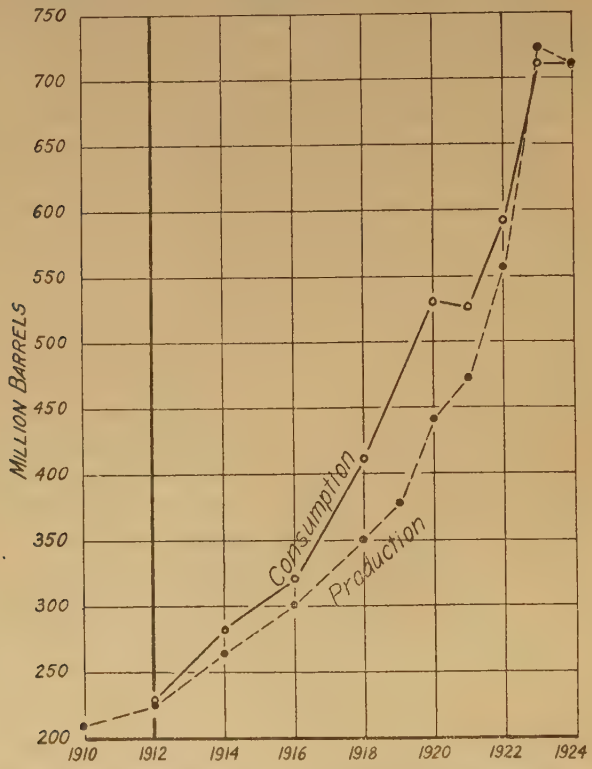

Fig. 1.—Production and consumption of crude oil in the United States (exclusive of exports of refined products).

The deficiency between supply of and demand for petroleum has been met by importations from Mexico and to supply the deficiency the United States has taken 60 per cent of Mexico's production. This Mexican production has been almost all from one general oil-producing zone, a zone that apparently is now well on its way to speedy exhaustion. The future production of Mexico and other countries of the Western Hemisphere is problematical, and may be dependent on higher prices for

oil to pay the increased costs of production in remote places and of pipeline transportation from inland fields to tidewater.

The largest producing oil district in the United States is that of Oklahoma, Louisiana and Northern Texas. Accordingly, the price changes of this "mid-continent" crude oil largely determine the market price of crude oil from the other American fields. The variation of price of oil is shown in Figure 2.

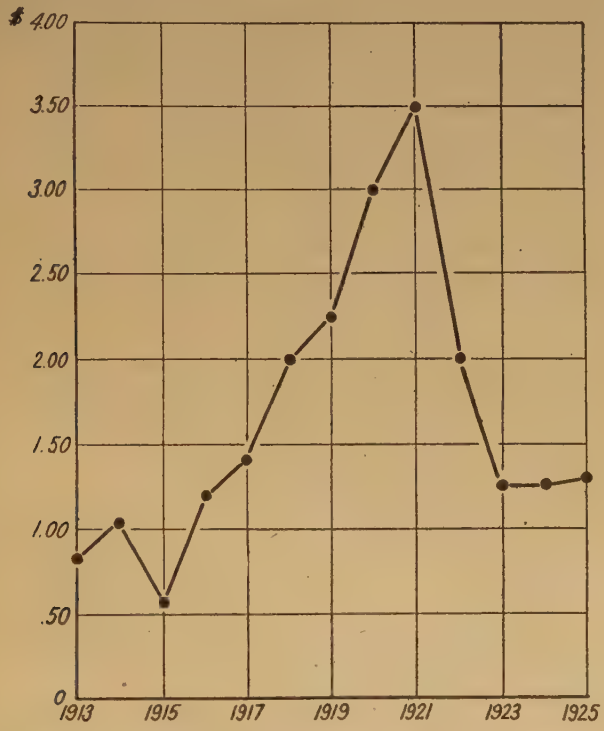

Fig. 2.—Price changes of Mid-Continent crude oil (January prices).

At the present day the automotive industry practically carries the petroleum industry. Although gasoline is only 25 per cent of the crude oil from which it is made, it yields half the revenue of the oil industry. In 1915 the average price of gasoline was eleven cents per gallon; in 1920 the peak price was three times as much and it has since fallen The yield of gasoline from crude oil in 1915 was 11 per cent, while in 1924 it was 36 per cent. The very rapid increase in gasoline production and consumption and the related growth of the automotive industry are easiest shown in the form of tables and curves.

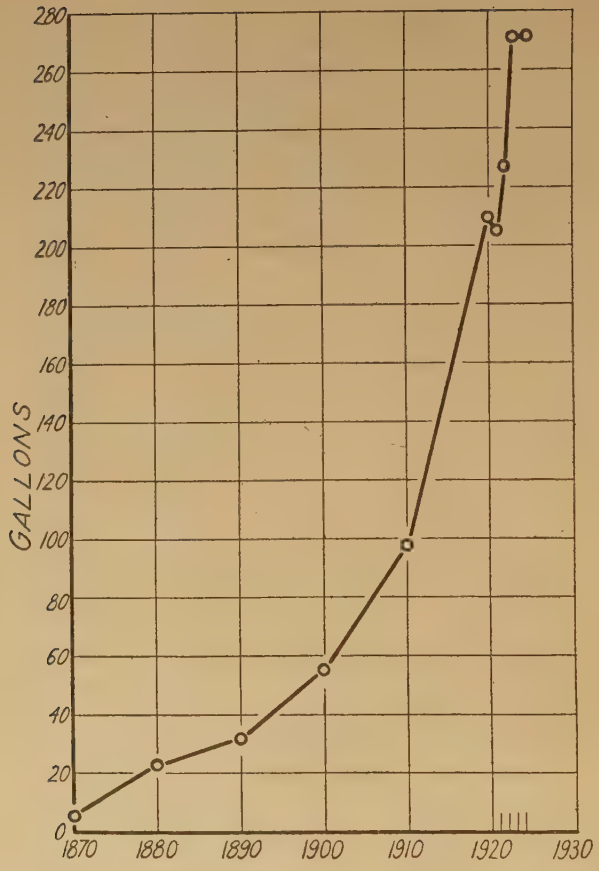

Fig. 3.—Per capita consumption of petroleum in the United States.

TABLE I

Year	Gasoline Production in United States in Gallons *
1917	2,850,000,000
1918	3,570,000,000
1919	3,958,000,000
1920	4,882,000,000
1921	5,154,000,000
1922	6,202,000,000
1923	7,556,000,000
1924	8,956,680,000

* About 15 per cent of the total gasoline production is made by cracking heavier oils and about 12 per cent is recovered from casinghead gasoline.

Table I shows the rapid increase in gasoline production in the last few years. Figure 3 shows even better the past history of petroleum

consumption and its close relation to the automobile industry. Note that though the automobile was first used shortly after 1900, it did not become popular until about 1910.

Data of automobile production in the United States are given in Table II. It is difficult to estimate what the "saturation point" of the United States for passenger cars, trucks, and farm tractors will be, but it will probably reach a total of over twenty million. The total registration in the United States as of Jan. 1, 1925, was 15,597,628 passenger cars and 2,142,608 motor trucks. The Jan. 1, 1925, world registration of motor-driven cars was 22,700,094.

TABLE II

AUTOMOBILE PRODUCTION IN THE UNITED STATES *

Year	Passenger Cars	Motor Trucks
1912	356,000	22,000
1913	461,500	23,500
1914	543,679	25,375
1915	818,618	74,000
1916	1,493,617	90,000
1917	1,740,792	128,157
1918	926,388	227,250
1919	1,657,652	316,364
1920	1,883,158	322,039
1921	1,514,000	147,550
1922	2,406,396	252,668
1923	3,636,599	376,257
1924 (est.)	3,100,000	350,000

*Tractors are not included in this table, but amount to about half the number of motor trucks.

Even Figure 3, which shows the rapid per capita increase of petroleum consumption, does not tell the whole truth of the expansion, since the percentage of gasoline obtained from crude petroleum has been considerably increased by new cracking methods, by improved refining processes, and by lowering the grade of gasoline sold. By these methods a barrel of crude oil now yields as much gasoline as was obtained from three barrels of petroleum ten years ago. At present (see Figure 4) about 36 gallons of motor fuel are produced from each hundred gallons of average crude oil. On the basis of our present knowledge, it seems probable that in the future this yield can be increased to nearly 45 gallons of gasoline per hundred gallons of crude oil. The increased yield, however, will be at the expense of fuel oil, which has largely been substituted for coal, and eventually may tend to diminish the production of lubricants.

There has been no commercial cracking of shale oil. The results

obtained in experimental laboratory runs, however, indicate that shale oil cracks to form gasoline as and with as good yields as ordinary well petroleum and that the resulting crude gasoline can be readily handled by refining processes of the ordinary type.

It is apparent that in the near future a shortage of petroleum and

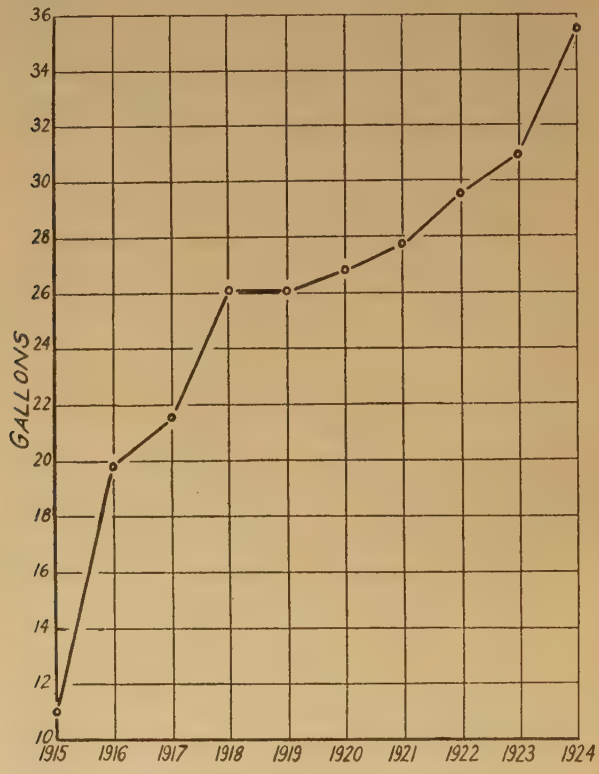

Fig. 4.—Gallons gasoline from 100 gallons crude oil.

gasoline may be expected. The probable most important methods of meeting this shortage are discussed below:

1. The price of oil products may be increased, and this will lead to greater economy in the use of petroleum and to the use of lighter cars which will give greater fuel economy than present American automobiles. Consumption of gasoline per car per year has already fallen from 600 gallons to about 400 gallons. It is worth noting that in this country 30 cents a gallon is considered a high price for motor fuel, while in most other countries gasoline at a price of 50 cents a gallon is considered reasonable.

Automotive engines may be modified or redesigned to use a fuel less volatile than present-day motor fuel, and thus permit the use as motor fuel of a larger fraction of crude petroleum than is now possible. Change of engine design to obtain the advantages of higher compression pressures is certain to follow the development of "anti-knock" compounds such as tetraethyl lead, the mixture of small amounts of which with ordinary gasoline permits the use of high compression pressures without the "knocking" which would ordinarily result. The use of surface catalytic coatings, such as Katalite, on the walls of the combustion chamber of the motor promises decidedly greater mileage from a gallon of fuel.

Fig. 5.—Oil shale in place.

All these factors will increase fuel economy and go far to forestall the impending shortage of motor fuel.

2. Use of coal by-products and alcohol. Benzene, an oil more commonly designated by its German name "benzol", is a by-product recovered in making coke from coal by modern methods. It is much used as a motor fuel in continental Europe, though it freezes at a relatively high temperature (42° F.) and tends to give excessive carbon deposits in engine cylinders. Since it is a by-product of coke manufacture, increase in demand for benzene will not materially influence its production. In this country benzene has been used commercially as a motor fuel only when mixed with other fuels such as gasoline or alcohol.

Much has been said and written to the effect that alcohol and alcohol-

ether mixtures will be the motor fuel of the future. In tropical countries alcohol may ultimately be an important motor fuel, but it is not likely to be in the United States. No method is known of getting even fair yields of alcohol from wood and, on the other hand, starch and sugar crops are too valuable for human and animal food to permit the use of the necessary acreage for growing such crops primarily for alcohol production. However, alcohol production will undoubtedly be increased by more complete use of waste molasses from sugar production, of the waste liquor from sulfite pulp and of the culls and occasional overproduction of starch crops such as potatoes, sweet potatoes, corn, etc.

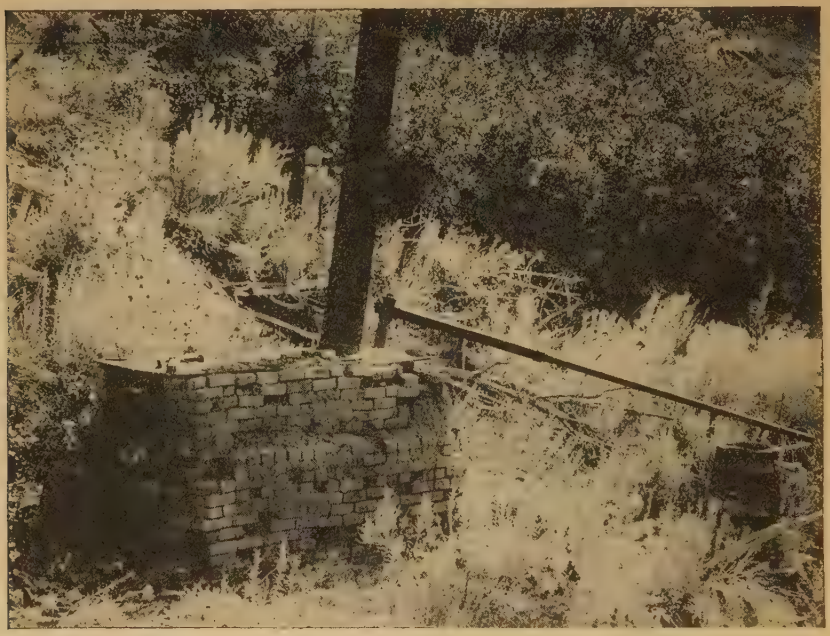

Fig. 6.—Old shale still of Mormons, near Juab, Utah.

Alcohol is a satisfactory motor fuel and in engines properly designed gives high efficiency even though its calorific value is low. When alcohol is mixed with ether, as it normally is in motor fuels, the ether increases the tendency of the engine to "knock". It is also difficult to obtain the mixture free from traces of acetic acid, the presence of which causes corrosion of storage tanks and shipping containers. This corrosion and also the detonation ("knock") can be reduced and even avoided entirely by adding such a material as aniline, the use of which is limited by its high cost.

3. When oil shale is heated in closed retorts, it yields an oil known as shale oil. From this shale oil motor fuel of the gasoline type can be obtained in quantity by refining methods generally of the same nature as those used in refining petroleum. As has been stated earlier in this chapter, enormous amounts of oil shale are available and accordingly the available crude petroleum and gasoline are dependent only upon a knowledge of adequate technical methods, coupled with the installation of proper plants for mining, retorting, and refining. With proper technical knowledge and proper equipment, commercial shale oil production will come as soon as it can be produced profitably.

Oil shale mining methods are generally similar to bituminous coal mining methods. Because of the greater toughness of oil shale, about a third more dynamite is required than for mining coal under parallel conditions, but, on the other hand, often there may be no objection to the formation of the fines which are so objectionable in coal mining. Auger drills have been satisfactory for mining oil shales in Scotland and also for some American shales, though much is yet to be learned regarding mining methods and equipment for all our most important deposits. In underground mining a seam about three feet thick is the minimum working vein of oil shale. Eighteen cubic feet of average oil shale in place weighs a ton and when broken it occupies two-thirds more space. On the basis of Scottish practice the mining waste will average about 20 per cent. In the United States mining of oil shale is greatly facilitated by the horizontal position of the deposits and their height above the valleys, where the retorting plants would be located. The shale strata in many of the deposits are exceptionally thick and rich. It is not probable that gas and dust explosions will be a hazard in most oil shale mining, though experimental evidence indicates the possibility of danger from dust explosions when rich shales are to be mined.

The underground miner may be expected to mine a maximum of ten tons and an average of six tons of oil shale per day. The coal miner ordinarily works less than a total of six months a year because of the seasonal demand for coal and frequently inadequate transportation equipment. In an oil shale mine employment should be nearly continuous, as the product will be used at the point of production and seasonal variations can easily be taken care of. This will mean a more stable type of labor and, correspondingly, a relatively lower mining cost than for coal.

Some American and foreign oil-shale deposits are at or near the surface and thus can be mined by power or steam shovels. These few deposits, accordingly, may be mined at costs much less than those of the many deposits which will have to be mined by underground methods.

The present United States law no longer permits oil shale claims to

Fig. 7.—Breaker of Broxburn plant, Scotland, with pile of shale tailings in background.

be located and brought to patent and private ownership by assessment work on the claim and payment of the government fees. Although there has been great interest and activity in oil shale lands, but one oil shale lease has been filed under the new Land Leasing Law which went into effect in February, 1920. The various corporations and individuals which have made real investments in oil shale land have exclusively taken up land under private ownership, i.e., land taken from the Government under laws in force previous to the present oil shale land leasing law.

Regulations pertaining to oil shale leases on public lands under the general land leasing law are objected to by many who are interested in oil shale development. The regulations have not been tested in actual oil shale leases, though the regulations of the same law applying to oil leases are in satisfactory operation.

Those who find objections to the general land leasing law emphasize the following among other requirements as those which would so affect a manufacturing plant such as a shale oil plant that the law could not be obeyed without forcing the plant into bankruptcy.

1. Products of plant shall be sold at prices acceptable to the Secretary of the Interior (§ 5 of Lease).

2. The company must not assign or sublet the lease (§ 4 f). In other words, the company cannot issue bonds or preferred stock or in any way offer its property, including lease, as security for any loan needed by the company.

3. "A royalty of .... per centum of the market value" of the products is charged (§ 6) independent of whether the products are crude oil or those refined products on which much labor and expense have been expended.

4. The Secretary of the Interior fixes new royalties at the end of each twenty years, and even if these royalties are excessive the plant management must accept them or give up its lease and property to the Government (§ 10).

5. The plant must leave "no available mineral abandoned where mining is being conducted" (§ 4 g). The Government has indicated that oil shale yielding 15 gallons a ton is "commercial shale" and accordingly it might compel a plant to mine this shale, though it sent the company into bankruptcy, rather than permit the mining only of the shale yielding above, say, 30 gallons oil per ton and make a profit thereby.

It has been shown earlier that the demand for petroleum in this country is increasing at the rate of over fifty million barrels a year. If this increase continues it will require each year seventy-five new plants, each handling 2000 tons of oil shale a day, and representing an investment of perhaps a million dollars each, to produce sufficient oil to meet simply this yearly increased demand. Other than shale oil there is in

prospect no source of fuel oil or gasoline or gasoline substitute which promises to furnish even a minor part of this demand.

Shale oil is now giving commercially, though not in large quantities, motor gasoline, tractor fuel, kerosene, light lubricating oil, medium lubricating oil, flotation oil and paraffin wax of several grades. So far a satisfactory heavy lubricating oil has not been made from shale oil. However methods of refining shale petroleum different from those in common use for well petroleum will undoubtedly be developed and with such a development different and additional useful products will undoubtedly be made.

CHAPTER 2

ORIGIN OF OIL SHALES

By R. D. George

Nearly all black shales owe their color to the presence of carbonaceous matter derived from plant or animal remains. Depending upon the extent of the change which these shales have undergone since their deposition, the organic remains may still retain much of their original form and composition, or they may have been partially or wholly bituminized. In this process they lose very largely their original form and undergo important chemical changes, in which much of their volatile matter is lost. The extreme change is characterized by the loss of all volatile matter and the separation of free, residual carbon: the graphitic shales are thus formed.

Black shales containing volatile carbonaceous matter and, therefore, capable of yielding inflammable gases and oil, occur in the sedimentary formations of practically all geological ages from the Belt series of pre-Cambrian age to the peat-bog clays in process of formation today.

But if, in using the term "oil shale", we limit its application to shale which may be regarded as a possible commercial source of oil, only a very small percentage of the shale of this or any other country will be classed as oil shale.

The name "oil shale" has been applied to deposits of widely different character and origin, but having the common property of yielding oil by distillation. These deposits may be grouped as:

1. Shales partially or completely saturated with oil from an outside source. Evaporation and other changes may have converted the oil into a bituminous or carbonaceous residue.
2. Lignitic and coaly shales.
3. Torbanites, including Boghead coal, kerosene shale, cannel coal.
4. True oil shales.

From groups 2, 3 and 4 *oil or other bituminous matter is obtained in commercial quantity only by destructive distillation.* They are largely or wholly pyrobituminous.

In deposits of the first group the oil fills the pores and joint spaces, and follows the openings along stratification and fault planes. By fol-

lowing joints and stratification openings it may surround but not saturate masses of fine textured but slightly porous rock. The outer borders of the deposit will be very irregular, owing to further penetration of the oil along the more porous strata. These shales yield the ordinary odor of petroleum without being bruised or cut. In the laboratory the liquid oil is easily removed by gasoline and other solvents, and even the residual bitumen resulting from inspissation is commonly quite readily soluble.

Those of the second group always contain films or laminae of fairly pure, friable coal between layers composed largely of inorganic matter but containing many grains and much powder of a coaly character. When burned they yield the characteristic odor of burning coal. The oil distilled from them is rich in aromatic hydrocarbons, and contains other characteristic products of coal distillation. It commonly smells distinctly of phenols (carbolic acid).

The deposits of the third group are well represented by the torbanite of Bathgate, Linlithgowshire, Scotland, and the kerosene shales of New South Wales. They may be regarded as the middle member of a series including oil shales, torbanites and true cannel coals. The leaner and less coaly torbanites grade downward into oil shales. The more coaly torbanites grade into the true cannels. Under certain conditions of deposition the biochemical, chemical and dynamochemical processes at work on the organic matter were so controlled and correlated as to convert it into the raw material for future oil fields, but the earth movements necessary to the actual distillation and storage of oil did not occur, and the deposits are still in the oil shale stage. Under other conditions the operation of these processes were so controlled and correlated as to produce true cannel coal. Between these extremes were conditions of deposition which so controlled and correlated the operation of the processes of change as to give a product intermediate in character between an oil shale and a typical cannel—that is to say, a torbanite.

In many oil shale deposits there are gradations to torbanite and to cannel.

In the fourth group are what may be called the true oil shales, though no clear-cut dividing line can be drawn between them and the poorer torbanites. Here belong the oil shales of Scotland, France (in large part), New Brunswick, Nova Scotia (largely), Colorado, Utah, Wyoming and many others.

They are shales in which organic matter was intimately mingled with inorganic matter at the time of deposition and subsequently became altered (bituminized) in such a way as to yield petroleum by destructive distillation.

They are not merely porous shales into which oil or other bituminous

matter has penetrated. An examination of true oil shales rarely reveals the presence of oil as such. But if deeply buried oil shales in contact with porous strata were subjected to the geodynamic processes which have produced oil fields, the distillation and storage of oil would take place and an oil field would be formed. The free oil occasionally found in oil shale deposits may have been developed by dynamic processes too feeble or of too short duration to carry to completion the making of an oil field. In some deposits the presence of free oil is due to the intrusion of molten igneous rocks. In others the oil may have seeped or filtered into the strata.

Solution tests show that but little of the oil obtainable from the normal dry shale exists in the rock as true hydrocarbons. If bituminous matter had seeped into the rock series containing the oil shale strata it would have chosen the porous layers, but it is a notable fact that in many cases the sandstones associated with oil shales are extremely poor in organic matter, and that the richest shales are the closest textured, and least porous. In many shales the volume of kerogen far exceeds that of the inorganic matter. When a chip of rich shale is leached of its inorganic matter and softened by alkali it consists of a spongy matrix of extreme fineness in which may be bedded identifiable plant remains. Under the microscope a thin section of the rich shale shows an extremely fine ground mass of more or less altered (bituminized) plant matter in which are bedded such highly resistant plant remains as spores, spore cases, pollen and pollen exines, grains of resin and wax. The less rich shales, in many cases, show a larger proportion of recognizable material, among which are shreds and fibers of the less resistant plant matter, and cell structure may be observed. It is mainly from these substances that the oil is formed when the shales are subjected to destructive distillation.

The general similarity of the geology of oil shales to that of coals suggests that the geological conditions and processes favorable for the making of the one were also those required for the making of the other. Both were formed in swamps, lagoons, deltas, estuaries and lakes.

The waters of the basins were prevailingly from the land, and fresh, but occasionally the coastal basins were invaded by the sea and brackish or marine water conditions existed temporarily. A few coal and a few oil shale deposits were probably formed largely or wholly under marine conditions. Until quite recently it was commonly held that the atmosphere of coal-making periods was especially rich in carbon dioxide and was otherwise unlike that of the present; that the climatic conditions were unusual, and that a highly specialized vegetation formed the deposits which later became coal. Later study has shown that the coal deposits were formed from the characteristic vegetation of the period under an

atmosphere not unlike that of the present and subject to normal climatic conditions. In brief, it has been shown that the coals were developed from deposits formed just as the peat deposits are being made today—that peat formation is the first stage of coal-making.

Rich oil shale is of exceedingly fine texture, breaks with a smooth conchoidal fracture, has a dull silky or satiny luster, and when unweathered shows but little evidence of structure. It kindles readily and yields a relatively large amount of volatile matter. In these particulars it resembles cannel coal. An examination of thin sections under the microscope reveals the presence of vegetable matter in various stages of disintegration, from shreds of wood, bark and leaves retaining their normal forms and cell structure, to a matrix evidently composed very largely of vegetable matter so completely macerated or pulped as to retain no identifiable features. In these respects it resembles lignite and sub-bituminous coal. In addition to these materials, spores, pollen grains, exines of spores and pollen, grains of wax and resin are sometimes abundant. In cannel coal these substances greatly predominate. Under heat many of the richer shales coke, and in this respect they resemble the coking coals of the bituminous group. Inorganic matter is abundant, extremely fine and is intimately mingled with the organic material. It consists mainly of clay, but fine sand, calcium carbonate, iron oxides and iron carbonate are commonly present. Iron sulfide, in the form of marcasite and pyrite, is a common constituent. Animal remains such as those of fish, crustaceans (especially entomostraca), insects, larvae and others are common in some oil shales. The Utica shales and Kimmeridge shales contain abundant aquatic faunas. Animal remains of various kinds are also found in the coals, but are less abundant than in oil shales.

The masses of vegetable matter which developed into coal were formed in basins from which for long periods of time inorganic sediments were shut out. Periods of accumulation were abruptly ended by the incoming of inorganic sediments forming strata of greater or less thickness over the vegetable matter and effectively sealing it from the atmosphere and the agencies of subaerial decay.

Oil shales were formed in open basins in which the deposition of inorganic sediments went on without important or long continued interruption during the accumulation by growth (or otherwise) of the vegetation which forms the carbonaceous and pyrobituminous matter of the shale. The relative proportions of organic and inorganic matter vary widely in the oil shale strata, and may be due to variation in the rate of vegetable accumulation or the rate of inorganic sedimentation or both. So far as the central portions of the basins were concerned only the finest sediments were carried in, and at times the amount was so meager

that it did not smother even small and very frail plants rooted in the muds of the basin floor. In the Colorado oil shales the microscope shows the presence of very delicate, soft bodied plant forms, possibly algae, which were slowly buried in their growing positions. The kerosene shales of New South Wales contain many rhizomes of Glossopteris in their growing positions. Shells of lingula are found in the Scottish oil shales in the positions characteristic of life.

The very diverse character of the plant remains in certain oil shales suggests that some of the material was floated to its place of burial, that other was carried by the wind, and that in places a very considerable part grew where it is now buried.

In some shales the presence of strata containing great numbers of curled, polygonal chips of sun dried clay shows that the floors of the basins were, at times exposed as mud flats, but such periods of exposure appear to have been short. In a number of shale deposits small lenses of torbanite and impure cannel coal show that in parts of the basins the supply of oxygen was sufficient to permit rapid biochemical and chemical changes in the vegetable matter. The rate of inorganic sedimentation was too slow to bury the material and check these changes until they had accomplished the destruction of all but the most resistant parts of the vegetation such as spores, pollen, spore and pollen exines, resin and wax, the materials of which cannel coal is largely composed. These conditions may have occurred where there was a sufficiently rapid exchange of water to effect oxygenation, but too far from the margins of the basin to receive much inorganic matter.

Such appear to have been the general conditions under which the oil shale strata were formed. Following these periods were times in which the sediments deposited contain little or no organic matter. In some places the changes are abrupt, in others very gradual. The change of the lake floor from a garden crowded with vegetation to a barren mud or sand expanse may have been due to the deepening of the basin to such an extent that plant life ceased or became very meager; or it may have been caused by such rapid sedimentation that all plant life was smothered, and for a long time did not again get possession of the lake floor. If the change were due to deepening of the waters there would be a return of the vegetation when sediments had again filled the lake so that the bottom lay within the zone of depth at which plant life could flourish. If it were due to too rapid sedimentation it must have been accompanied by subsidence of the lake floor in order to make room for the considerable thicknesses of strata practically free from organic remains. These periods of dominantly inorganic sedimentation ended with a return of vegetation of the same kind and characteristic of the same depth of water.

The changes which mark the passage of vegetation to coal may be classed as biochemical, chemical and dynamochemical. Fungi and bacteria are chiefly responsible for the biochemical changes. The strictly chemical are attendant upon and consequent to the biochemical. The dynamochemical are confined largely to the period following the burial of the plant material.

The materials of which plants are composed are many, and possess widely differing powers of resistance to the agencies of decay. Coals are formed very largely of residues from plants, and the longer the agencies of decay worked upon the plants, and the more unhindered their operation the more completely are all the readily destructible parts removed and the greater is the proportion of the resistant parts such as spores, pollen, spore and pollen exines, waxes, resins and fats. Thus it comes about that the higher grades of cannel are composed very largely of spores, spore exines, resins and cuticles.

In the coal basins the processes of disintegration would go on largely unhindered. In the oil shale basins the conditions of life—both of the plants forming the carbonaceous part of the shale and of the fungi and bacteria responsible for the biochemical changes—would be very different. The prompt burial of the plant remains would retard if not stop entirely the activities of these organisms. The clay would also modify the purely chemical processes by shutting out oxygen from the vegetable mass. Putrefaction is notably retarded and under certain conditions arrested by contact with clay. The period of operation of these agencies would be much shorter and their work would be much less complete. As a consequence we find in the Tertiary shales of Colorado, algae and other plant remains only slightly altered. The dynamochemical processes would not be the same under the different modes of burial of the oil shale-making plants and the coal-making plants. In most shale deposits these processes have progressed slowly on account of the nonporous enclosing clay which would prevent the escape of the gases formed, and retard devolatilization.

In the matter of condition of the plant remains lignite bears the closest relation to oil shale. In general the lignites are the later coals and the agencies of change have operated on them a shorter time. Many of the oil shales are geologically very old but the conditions of formation and burial retarded and arrested the processes of change, and the results are comparable in these respects.

The texture of cannel coal is due to the extreme fineness of the component plant matter. That of oil shale is due to the extreme fineness of the inorganic matter which usually forms the greater part of the mass. The similarity of fracture is a natural result of the fineness of texture. The relatively high amount of volatile matter of the oil shale

is probably due to the slow loss of the volatile content through the protection afforded by the clay in which the débris is buried. Lignite is high in volatile matter because of the incompleteness of chemical and dynamochemical changes. In part, the high volatile content of shales is due to the very large proportion of spores and like matter it contains, and the very slow progress of devolatilization of these very resistant materials.

The coking of coal is believed to be due to the presence in the coal of true hydrocarbons of certain forms. That true hydrocarbons exist in the richer oil shales there can be little doubt.

The laboratory history of the coal basin differed in many respects from that of the oil shale basin, and the finished products are correspondingly unlike.

It may be said that lean oil shale and rich cannel coal form the extreme ends of a series in which there are no abrupt breaks. This is true as to the proportion of organic and inorganic matter in the original deposits, and in the extent or completeness of the biochemical, chemical and dynamochemical changes which have taken place. In the shales the more resistant materials are mingled with less resistant matter in varying proportions. In the cannels the more resistant or end products of change predominate. The development of true hydrocarbons has scarcely begun in some shales, whereas in cannels it appears to have advanced far.

Concerning the part contributed by animal remains to the pyrobituminous matter of oil shale, there appears to be wide difference of opinion. So far as the Colorado, Utah and Wyoming shales are concerned there is but little evidence to show that they have contributed in any appreciable way. Of many slides examined not one showed a recognizable trace of animal remains. On the other hand the Utica shales are rich in animal fossils, but contain little or no recognizable plant matter. The Kimmeridge shale of England contains a rich Jurassic fauna. Many fish remains are found in the Scottish and New Brunswick shales but in most of them plant remains predominate. Entomostraca shells are extremely abundant in the rich torbanite shales of Queensland, and one writer says that plant remains are scarce. The oil shales of Brazil contain organic remains of both kinds. Shales from Peru yield an oil having an odor closely resembling that of pine tar, but neither plant nor animal remains are recognizable in the material examined. The Ohio shales are rich in spore cases of rhizocarps allied to Salvinia of the present day.

It would seem probable that both plant and animal remains may contribute to bituminous matter, but the weight of evidence favors plant remains as the important source of the hydrocarbons. The close geo-

logical relationship of oil shales and coals points in the same direction. There is nothing in the character of shale oil which would aid in deciding its ultimate origin.

With respect to the resinous character of the spores, it has been pointed out that resins when subjected to destructive distillation yield aromatic hydrocarbons, whereas the destructive distillation of oil shales rich in spores and pollen yields mainly paraffins and olefins. Resins are more or less soluble in alcohol, ether, naphtha, and oil of turpentine, but many oil shales containing these bodies are very slightly acted on by these reagents or by carbon bisulfide, benzol, carbon tetrachloride and other similar solvents.

Many widely differing theories have been advanced regarding the origin of torbanites and oil shales. The following quotations and abstracts will serve to illustrate the range of views.

After discussing certain features of the kerosene shales of New South Wales Professor David says: "It is possible, therefore, that the oily character of these shales may be chiefly due to the local accumulations of showers of minute spores or sporangia or seeds, with a certain admixture of peaty material from the swampy ground in which the (associated) coal was formed. . . . Examined under the microscope by transmitted light, the small, spherical, resinous-like bodies, of which the shale is chiefly composed, are seen to possess a decided organic structure. . . . Numerous aggregations of minute spindle-shaped or club-shaped bodies are seen to occur in each globule, and recall the appearance of zoöspores in some forms of algae. . . . At all events, in the present state of our knowledge, it may be asserted that kerosene shale was probably formed in lakes, and that it was formed from minute plant bodies, probably either sporangia or algae."

Dawson, J. W. (Acadian Geology, p. 339 of 1868), in speaking of stellarite (which must be classed as torbanite or very rich oil shale). says: "The mineral known as stellar coal is, as I have maintained in previous publications, of the nature of an earthy bitumen, and geologically is to be regarded as an underclay or fossil soil, extremely rich in bituminous matter, derived from decayed and comminuted vegetable substances. It is, in short, a fossil swamp muck or mud."

Many authors note the very frequent transition from boghead and cannel coal to oil shales, and express their belief in a common mode of origin.

Cadell, H. M.[125] in discussing the Scottish shales states that Entomostracans, with fish and plant remains are exceedingly common and that Entomostracans compose the body of the Gray Shale in which they occur "squeezed together like grains of linseed in a piece of oil-cake."

In a recent paper [500] before the Mining Institute of Scotland the

same author states that the most natural explanation of the origin of oil shale is that the shales were originally beds of fine silt or clay, deposited in lakes or lagoons near the shores of a Carboniferous land area, and the impalpable mud was mixed with a large quantity of vegetable or animal matter, like the black vegetable slime that was washed off a peat moss.

Bertrand and Renault (Soc. d'Histoirre Naturelle d'Autun, Bull. *9*, pp. 193-292, 1896) believe that the bodies called spores and resinous masses by Dawson, David, Balfour and Huxley were gelosic algae, similar to Volvocineae, and which, together with other vegetable débris, were suspended in a fundamental jelly which they called Phytozymase. The algae were supposed to collect and become impregnated with bituminous matter from outside sources, thus giving the bitumen content of the shale. White [160] accepts rather fully the findings of Bertrand and Renault, and says that the bituminous matter might be "derived from the decomposition of the associated faunal elements, or perhaps in part from the putrefaction of great numbers of the original algae." He found that micro-algae formed "a considerable part of the oil shale reported to have come from the Permian of Brazil and the Eocene of Arkansas."

In discussing the origin of the oil shales of Colorado, Utah and Wyoming Davis says (U. S. Geol. Survey, Bull. 691 of 1919): "The rich shales are very compact and almost as impervious as rubber, being made up of what seems to have been partly decomposed remains of minute plants, algae, fungi, spores, pollen, bacteria, etc., embedded as a jelly-like mass; between these there are few, if any, interspaces, and such grains of mineral matter as are present seem to be firmly embedded in this jelly-like mass."

Davis finds no evidence in the character or distribution of the oil yielding material which points to infiltration of bituminous matter from an outside source. On the contrary, every detail of the occurrence is consistent with the theory of the contemporaneous deposition of the oil-making and inorganic materials of the shales.

E. H. Cunningham-Craig in his book on Oil Finding holds that: "Oil-shales are adsorption phenomena due to the so-called affinity of certain argillaceous deposits for petroleum. . . . Oil-shales are often the last relics of a former impregnation with petroleum . . . but in many cases the parent oil fields, the sources of the former impregnation, are things of the past."

"The characteristic that determines that a bed or stratum should become an oil-shale is its absorptive and adsorptive capacity; the oil that impregnates it, or has at one time impregnated it, is adventitious."

The absorptive and adsorptive capacity depends upon the presence

of colloids, and fine clays, chiefly composed of finely divided silica, alumina, and ferric oxide, and poor in lime and magnesia.

"An oil-shale, then, is a combination between the disperse phase of the colloid solution or sol known as crude oil and the mineral colloids of a fine clay of suitable composition."

With regard to torbanite Craig holds that: "They are essentially beds of impure vegetable debris, and are usually classified as cannel coals of a somewhat special type."

"As seen under the microscope a torbanite consists of a coal matrix, in which globules of yellow or red-brown matter, spherical or ovoid in shape, are scattered more or less thickly. These globules consist of hydrocarbons and inorganic matter so intimately combined that they cannot be resolved by ordinary microscopic means."

These globules are doubtless the resins and waxes and possibly, in part, the spores as determined by Dawson, Balfour, David and other observers.

Thiessen, Reinhardt, finds that the Chocolate shale of the Devonian of Illinois is composed of a clay matrix in which are varying amounts of pyrite, and organic matter. When the organic matter is removed the shale may, or may not, have strength enough to retain its form. When the inorganic matter is dissolved out there remains a brown, soft light matter which may be quite compact but highly fissile, or may form a delicate structure readily disrupting into an ooze-like material.

Spores of different kinds and spore fragments form a large part of the organic matter. The other organic material consists of plant disintegration products, dark material in streaks, globules to flat fragments and cuticular remains.

He finds the Scotch shales are very similar in make-up to those of the Devonian of Illinois, Indiana, and Kentucky, but contain more pyrite and more resinous-appearing bodies of roughly rounded shape. The Pottsville shale of Kentucky is similar, but contains a "larger amount of recognizable plant fibers, especially wood fibers, cuticular matter and charred plant material." He thinks the Colorado, Utah and Nevada shales differ from the Devonian oil shales of the east.

CHAPTER 3

GEOLOGY AND DISTRIBUTION OF OIL SHALES

By R. D. George

THE OIL SHALES OF CANADA

By S. C. Ells

The geology of oil shales can best be presented by brief descriptions of a few of the typical and best known deposits. While the kerosene shales and other torbanite deposits are by many considered not strictly oil shales, they are so closely allied to the oil shales that it seems desirable to include here a brief description of one of the deposits, in the following section on the distribution of oil shales.

The oil shale deposits of Scotland, England, Colorado, Utah and Wyoming, Canada and Brazil have been chosen for specific geological description. The best known and most extensively developed torbanite deposits are those of New South Wales, which are also described.

The Oil Shales of Europe

The search for liquid fuels and for various other hydrocarbon products in Europe has led to the discovery of oil shale, lignite shale and cannel shale in many countries. True oil shales occur in Spain, France (including Alsace-Lorraine), Germany, Austria-Hungary, Italy, Bulgaria, Serbia, Turkey, Russia, Esthonia, Norway, Sweden, Scotland, England and Wales. The so-called shale oil or shale tar industry of Germany depends mainly, if not entirely, upon lignitic shales and bituminous lignites for its raw material, but true oil shales occur in Swabia and elsewhere, and it is reported that processes of treatment have been developed which make it possible to treat even low grade shales profitably.

The Geological age of these various deposits ranges from early Paleozoic to late Cenozoic, and the geological conditions of their occurrence are remarkably variable. In general they are of fresh or brackish water origin, but some are probably of marine origin.

Great Britain

Skye and Raasay

Oil shales of considerable promise occur in the Great Estaurine Series (Jurassic), on the islands of Skye and Raasay. One seam is from 7 to 10 feet thick. Intrusive rocks have caused profound alteration in some parts of the deposit.

Scotland

The oil shales of Scotland [198] lie on both sides of the Firth of Forth in Mid Lothian, West Lothian, Lanark, Peebles and Fife. They occur in the upper division of the Calciferous Sandstone series which lies between the recognized lower Carboniferous formation, and the upper Old Red Sandstone of the Devonian system. Beds of low grade coal occur in the upper part of the Oil Shale group, and lower down are commonly six or more seams of oil shale interstratified with sandstones, shale, fire clay, marls, and limestone. The strata vary locally in lithological character and there are, all told, about twenty workable seams of oil shale.

The oil shale is a fine-grained brownish, or brownish black and black clay shale readily distinguished in the field. The workable shales are interstratified with lean or barren beds into which they merge both along the stratification and across it. They are free from grit and cut readily with a knife. Two structural varieties occur—the plain or massive and the curly.

The Carboniferous system of Scotland may be arranged in descending order into:

1. Coal-measures;
2. The Millstone Grit;
3. Carboniferous Limestone Series;
4. Calciferous Sandstone Series.

This last is divided into:

a. Oil Shale Group (Burdie House Group), 3,000 feet thick, containing, in its upper part, beds of inferior coal followed by about six main seams of oil-shale interstratified with sandstone, shale, fire clay, marl and estuarine limestone;
b. The volcanic zone of Arthur's Seat lavas;

c. The Cementstone Group—white sandstones and shales passing downward into grey, green and red shales, clay marls, and sandstones with bands of argillaceous limestone or cementstone. No oil-shales are known in this division.

The fossils of the Oil Shale Group indicate an alternation of fresh or brackish water and marine conditions.

The sedimentation is very irregular, but persistent beds occur. The strata were laid down in shallow water basins, the floors of which were subject to irregular, intermittent subsidence, and which were rarely connected with the open sea. Desiccation breccias and mud cracks are common, especially in the marly strata which form so large a part of the series. These facts clearly indicate accumulation under mud-flat conditions. The lateral changes are very numerous—sometimes gradual, sometimes abrupt.

Although the Calciferous series is widespread in Scotland the conditions favoring the deposition of oil shale of commercial quality and volume do not appear to have occurred outside the area named. Thin and lean bands occur in other localities, but are of no commercial importance.

The structural features of the oil shale area are:

1. A series of north-north-east and south-south-west anticlinal and synclinal folds, most of which are normal, but a few present vertical or overturned strata.

2. A series of more or less powerful faults traversing the folds in a general easterly or northeasterly trend. Trough faulting is characteristic, and frequently the displacement is large.

Igneous rocks occur as:

1. Contemporaneous interstratified tuffs.

2. Intrusive, including necks of tuff or agglomerate, and sheets and dikes of dolerite, basalt and diabase.

The effect of the intrusions on the oil shales is extremely variable. In some places they are practically unaffected, in others cavities in the rocks have been filled with pitch or solid paraffin from the hydrocarbons distilled from the shales, in still others the shales are completely destroyed for long distances from the intrusive rock.

Folding, faulting, irregularity of thickness and oil yield of the beds, their depth below the surface, and the presence of igneous intrusions render mining and general development difficult and expensive.

The available tonnage is placed at 482,000,000, with a possible tonnage of 884,000,000. In recent years the average oil yield has been 22 U. S. gallons per long ton. The richest shales yield 72 to 84 gallons of oil per ton.

England

The Kimmeridge Shales

The Kimmeridge Clays are the lowest division of the Upper Oölite, of Jurassic age. They are widely distributed in eastern England, and especially in Dorsetshire where extensive outcrops occur. In lithological character they range from true argillaceous clays to highly gritty or sandy clays. The oil shales occur in the true clays.

Extensive faulting has made the geological relations of the formation rather complex, but the detailed maps of the area serve to clarify conditions.

The Kimmeridge clays are of estuarine origin and range in thickness from 500 feet to 1,000 feet. The oil shale strata range in thickness from a few inches to several feet. They have been worked at intervals since 1848. They contain a characteristic fossil fauna, and in some of the beds the fossils are extremely numerous. The writer has made several tests to determine the oil yield of the Kimmeridge shales. The highest yield obtained was at the rate of 34 imperial gallons to the ton. The ammonia yield was higher than that of the Colorado shales, but apparently not so high as that of the Scottish shales. The richest of the shale beds is 2 feet thick and is known as the Blackstone. It yields 39 per cent oil and solid volatile products, and tests indicate a possible yield per ton of 67 gallons of crude oil, containing 20 per cent naphtha. It is reported that extensive deposits of workable shales have been found in Somerset and Devon.

The Norfolk Shales

The oil shales of Norfolk [288] are of Jurassic age, and exploration with core drills has proved that they underlie a very large area east of the Ouse River. In borings to a depth of over 500 feet several seams ranging from 4 to 11 feet thick have been penetrated. They are separated from one another by limestones and barren clay rocks with occasional sandstone strata. The oil shales are thinly laminated, porous to spongy in texture and are, in places, highly fossiliferous. They are believed to be of estuarine origin, as are the Kimmeridge shales of Dorsetshire.

Torbanite is associated with the shales and an important seam, known as the 11-foot seam, contains a core of torbanite material which yields, on analysis, at the rate of 85 to 95 gallons of oil per ton. The oil of the Norfolk shales comes from sources: (*a*) seepage oil filling pores and open spaces in the shales, and (*b*) oil which, as in other oil shales, is generated by the application of heat. Considerable gas is encountered in the shale beds. The seepage oil increases with depth and in some of

the openings it forms pools. The strictly shale oil yield is said to range from 40 U. S. gallons, per ton up to 90 or over in the torbanite shales.

The crude oil is said to yield 20 per cent gasoline, 29 per cent kerosene, 27 per cent lubricating oils, and certain valuable by-products. The nitrogen content of the upper seam ranges from 0.75 to 0.95 per cent, but the ammonium sulfate yield is only 22 to 23 pounds per ton owing to the fact that much of the nitrogen has entered into other compounds such as pyridines. The sulfur content of the shale and the oil produced from it is objectionably high.

Drill prospecting has proved the existence of billions of tons of shale of workable thickness and relatively high oil yield although the quality of the oil is low because of its high sulfur content. Along the western part of the area the shale beds can be worked by open pit methods as the overburden is light and easily handled. It consists of a few feet of soil and glacial deposits resting on a pre-glacial soil containing lignitized vegetable matter probably derived from the oil shale seams. The principal development was carried on at West Winch and Setch where extensive treatment works were erected, and mines opened.

Ireland

Oil shales of commercial quality are known in Ireland, but the strata are faulted and otherwise disturbed and are nearly all overlain by basalt.

Wales

The material distilled for oil in Flintshire, was probably cannel coal and the associated shales.

France

The so-called oil shales of France are shales containing bituminous material which may be removed by solvents. There may also be pyrobituminous material in some of the deposits, but the amount is small. If oil shales are pyrobituminous the French shales are not true oil shales.

Oil shales are widely distributed in France, but only in small areas do they occur in beds of sufficient extent and rich enough to be successfully worked [212]. These occur in the Department of Saone-et-Loire, Allier, Puy-de-Dome, and Basses Alpes.

The principal deposits are those of Autun (Sâone-et-Loire) and Buxiere-les-Mines (Allier), both of which have been continuously worked, the former since 1862, and the latter since 1858. At the Autun the seams of shale are from 2 meters to 2.50 meters in thickness except at the Telots where the seam is only one meter in thickness. This seam, how-

ever, includes a seam 25 centimeters in thickness of Boghead coal, which gives it value.

At Buxiere-les-Mines the thickness of the shale seam is about 1.30 meters, and the shale is worked in conjunction with a seam of coal 1.50 meters in thickness.

The shales are of Permo-Carboniferous age, and in places contain plant and fish remains in large numbers.

Spain

Oil shales of commercial promise both in quality and volume occur in the Pedro Martínez Basin, Granada, at Rubielos de Mora and at Mora.

At Puertollano in the province of Ciudad Real beds of impure coal and beds of oil shales associated with workable coal occur in Carboniferous strata. A 6-foot bed of oil shale yielding 30 gallons of oil per ton is being retorted with coaly shales. The extent of the deposit is not stated. In 1923 the plant was making 3,500 gallons of crude oil per day.

Italy

In Italy oil shales occur at Como, Vicenza and Verona, and some of the deposits have been developed.

Bulgaria

Extensive deposits of oil shales occur in Southwestern and south central Bulgaria.

The bituminous shale beds range from 9 to 150 feet in thickness. In these are rich strata of workable thickness. Systematic tests have shown that large volumes of shale will yield from 18 to 55 gallons of crude oil per ton. The better Scottish shales yield about 22 gallons per ton. From some of these shales the yield of light oils and ammonia falls below that of the Scottish Shales, but Kemper (Oil and Gas Jour., *18*, 96 of 1920) states that the yield of benzine, lubricating oil and paraffin wax is larger.

Esthonia

Rich oil shales occur in Esthonia, and considerable development has been done in the last five or six years. Pulverized shale has been used as a substitute for coal, and the oil distilled from the shale has furnished fuel for the principal railways of the country.

The principal deposit lies along the Gulf of Finland and is said to be 130 miles long and 15 miles wide. The shales are in Paleozoic strata which dip gently southward. The shale beds range in thickness from a few inches to three feet, and estimates of workable tonnage range

from 1,500,000,000 tons to several times that figure. Mining in the northern part of the area is carried on by steam shovel, but farther south the overburden is such as to necessitate shaft mining. The shales are very rich and reports indicate a yield of 70 gallons per ton.

Sweden

The "alum" shale deposits of Kinne-Kulle, Ostergothland are of considerable size and may be made to yield oil and ammonia in commercial quantities.

Russia

Oil shales are widely distributed in European Russia, and so far as may be judged from the meager reports available the country has large deposits of commercial grade.

The best known deposits are those of the provinces (or governments) of Tver, Simbirsk and Samara in southern Russia, and deposits near Leningrad. But it is reported that extensive deposits occur in north Russia also.

The Tver deposits at Korcheva and Ostashkov are readily available by steam shovel mining, are three meters thick, and are near both rail and water transportation. The high content of volatile matter, 35.0 per cent., suggests a coal shale rather than a true oil shale.

The shales near Leningrad are used as raw materials for gas manufacture in Leningrad, and directly as a fuel. This also suggests coaly shale.

The most extensively worked deposits are those of Simbirsk where the shale is 7 meters thick, and has a high volatile content.

Jugo-Slavia

The shales of Alexinatz were tested in one of the Scotch plants and were found to be unusually rich. The principal bed is over 90 feet thick and is overlain and underlain by beds of lower grade. Deposits also occur at Radovagne near Belgrade. The richer part of the shale yields about 15 per cent. of oil.

THE OIL SHALES OF NORTH AMERICA

Oil Shales of Canada

By S. C. Ells

Occurrences of petroliferous shales (commonly referred to as oil shales), within the Dominion of Canada, have been recognized for many

years. Nevertheless, with the exception of a comparatively brief period, Canada has depended, and still depends, largely on foreign sources for her supplies of crude petroleum and petroleum products. In 1859 near Collingwood, Ontario, and again in 1862 near Baltimore, New Brunswick, attempts were made to retort local shales. In each instance these attempts were abandoned owing to the rapidly increasing production of free petroleum from the newly discovered pools of western Ontario and

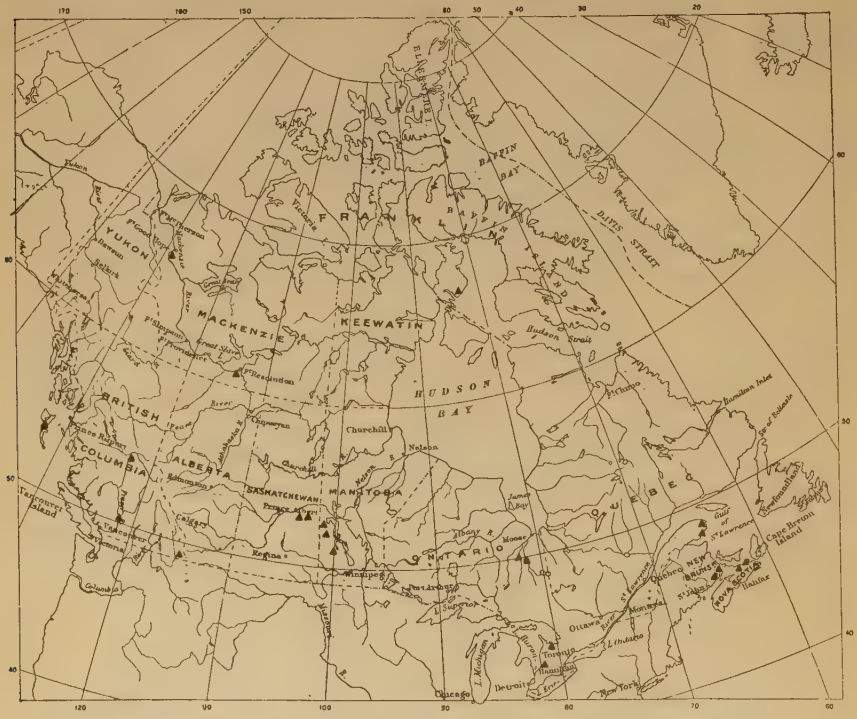

Fig. 8.—Index map, Dominion of Canada. Triangles show approximate position of oil shale areas.

of Pennsylvania. Now, after a lapse of nearly sixty years, and owing to recognized causes, attention is once more being directed to the potential commercial value of Canadian shales, as a possible source of crude petroleum.

It is thus only within very recent years, that changing economic conditions have appeared to warrant detailed study of various recognized shale bodies in Canada. Consequently, much work still remains to be done,—not only in the field but in the laboratory,—before the economic

importance of such areas can be definitely determined. Meanwhile, such information as is already available, may be attributed almost wholly to the Geological Survey of Canada. The writer is personally familiar with the oil shales of Nova Scotia, New Brunswick, Gaspé Peninsula, Northern Ontario, Manitoba and Saskatchewan. Reference to occurrences outside of these areas is based on information secured indirectly.

In the following briefly summarized references to known or reported deposits of oil shales (see Index Map), occurrences will be grouped under the Province or District in which each occurs. In discussing shales which vary widely both in physical characteristics and in hydrocarbon content, the use of the term "oil shale" is in certain instances provisional, and is necessarily applied in a broad sense.

In referring to the oil shales of Canada, it is not the writer's intention to discuss retorting methods and economic considerations. Reference to economic considerations would, of necessity, merely constitute a recapitulation of authoritative statements and conclusions. With these, all who are really interested in the commercial development of oil shales, are already familiar. Where oil shales can be cheaply mined by open-cut methods, with reasonably high recovery of petroleum and of ammonium sulfate, competition with well petroleum may be possible at the present time. Under conditions implying the adoption of underground mining methods, the possibility of present successful competition is by no means clear.

Province of Nova Scotia

The occurrence of oil shale in the province of Nova Scotia has been recognized for more than 60 years [174]. During the three years following its discovery, several thousand tons of a particularly rich subvariety, known as stellarite, (stellar coal or oil coal), was mined near Stellarton, in Pictou county. This output was derived chiefly from a rich band immediately underlying the McGregor coal seam; but shipments were also made from McLellan's brook, and from a point just west of Blackwood's mill dam. Poole states that stellarite from the first named locality yielded upwards of 10,000 cu. ft. of "36 candle gas," and that picked samples gave a yield equivalent to 170 Imperial gallons (204 U. S. gallons). of crude shale oil per ton. The average shale oil yield of a cargo shipped to Boston was 48 Imperial gallons (57.6 U. S. gallons), while the associated shale "bat," gave a yield of 39 Imperial gallons (46.8 U. S. gallons). Part of the above output was shipped to retorting works in Boston and in Portland, and part was mixed with bituminous coals for the enrichment of illuminating gas. Following the discovery of free petroleum in Ontario and in the United States the mining of stellarite ceased.

Oil shales of Nova Scotia are associated, in part, with strata of Lower Carboniferous age, and in part, with the Coal Measures and Upper Carboniferous rocks. The shales, as a whole, differ in character from those of New Brunswick, and with notable exceptions, as in Pictou county, are carbonaceous rather than bituminous. There is a general absence of the brown shales and hard massive oil bands, so typical of the New Brunswick field, and certain large deposits, which were at one time classed as oil shales, have been found to be too poor in hydrocarbons to warrant further consideration.

Areas of reported oil shales extend from near the mouth of the Avon River, to the vicinity of East Bay, Cape Breton. Certain of these will be briefly discussed.

Colchester and Hants Counties

Along the south coast of Minas Basin, heavy beds of shales are well exposed, notably at Cheverie, between Split Rock and the village of Noel, and on the west side of the Avon, between Hantsport and Horton Bluff. The complete series consists of quartzose grits, interstratified with thick bands of carbonaceous shales, similar to those of Hollowell Grant, Antigonish county, and East Bay, Cape Breton. Certain of these shales will burn, and have been used as a substitute for coal, while others, full of rootlets, constitute true underclays. To the north of Minas Basin, similar shales extend along the south flank of Cobequid mountains, and are well exposed along Moose river, Harrington river, on the North river near Onslow, and elsewhere. These shales were styled the Horton series by Sir Wm. Dawson, and have been correlated with the Albert series of New Brunswick. As a class they are deficient in hydrocarbons, although further detailed examination may possibly discover associated oil shale bands. With these beds are frequently associated beds of dirty coal, high in ash, and of little commercial value.

Pictou County

From present information, deposits of Pictou county comprise the most promising oil shales of the province of Nova Scotia. The principal occurrences noted are found in that portion of the Pictou bituminous coal field centering about the town of Stellarton.

The field has an area of approximately 20 square miles, and is chiefly occupied by Coal Measures and rocks of Lower Carboniferous age. Geological features of the area have been somewhat fully described in publications issued by the Geological Survey of Canada, and in papers presented before technical and scientific societies.

The field may be divided into two main districts, eastern and western. In the eastern district, coal seams occur in two horizons of the Productive Measures. In the upper horizon are five seams, varying in thickness from 3 feet to 8 feet. In the lower horizon, six seams vary in thickness from 7 feet to 45 feet. With these latter seams have been correlated the four principal seams of the western district. Interposed between the upper and lower coal horizons are strata consisting chiefly of dark shales, and having an aggregrate thickness of approximately 1600 feet. With these are associated the principal oil shale bands.

Major and minor faulting has affected the whole district in marked degree. A comparison of sections also indicates that coal seams vary widely in thickness from place to place, and that deterioration, due to replacement by shales and sandstones, frequently occurs within comparatively narrow limits. These features are of importance in considering the possible economic importance of associated oil shale bands.

Outcrops of certain of the more important bands of oil shale occur near the town of Stellarton and along McCulloch's brook, McLellan's brook, Marsh brook (a branch of McLellan's brook), Shale brook, on the south shore of Deacon cove, and near the mouth of Smelt brook. The position of these is indicated on Poole's map of the area issued by the Geological Survey of Canada in 1904. Of these oil shales, the subvariety known as stellarite, is particularly worthy of note. The following reference to this mineral is by Sir J. W. Dawson. (Acadian Geology, page 339) "The material known as stellar coal is, as I have maintained in previous publications, of the nature of an earthy bitumen, and geologically is to be regarded as an underclay or fossil soil, extremely rich in bituminous matter, derived from decayed and comminuted vegetable substance. . . ."

Stellarite underlies the McGregor coal seams at Stellarton, and also outcrops near the old Patrick slope in McLellan's brook and on Marsh

Locality	Imperial Gals. Crude Oil per 2000 Lb. Ton	U. S. Gals. Crude Oil per Ton	Sp. Gr.	Pounds Ammonium Sulfate per Ton
McLellan's brook (Patrick's slope)	38	45.6	0.892	41
McLellan's brook (Black old mill site)	15	18.0	0.889	35
Marsh brook (150 feet above McKay's house)	3	3.6	..	..
Marsh brook (300 feet above McKay's house)	14	16.8	0.903	..
Shale brook (upper end)	4	4.8	0.921	..
Shale brook (near forks with McLellan's brook)	9	10.8	..	..
Woodburn Sta. (one mile west of, on C. N. Ry.)	13	15.6	0.902	..

brook. The thickness of the various seams shows marked variation and, at different points, has been estimated as ranging from 1 inch to 8 feet.

The above analyses by the Canadian Department of Mines are based on samples of oil shales, other than stellarite, secured by the writer in 1909 from a number of outcrops in the Pictou field.

From the above analyses it will be seen, that, as a whole, shales from the localities noted, are not of commercial value. Results of analyses of shales (including stellarite), from Stellarton and McLellan's brook, indicate that the seams represented, are worthy of detailed investigation.

Antigonish County

Shales of Lower Carboniferous age occupy a basin lying immediately to the north of the town of Antigonish. For the most part the shales are black and carbonaceous, thus bearing a marked similarity to those of Hants county. A large number of samples was secured within this area by the writer in 1909, and results of the laboratory determination of the more promising of these are as follows:

Locality	Imp. Gals. Crude per Ton of 2000 Lbs.	U. S. Gals. Crude per Ton	Sp. Gr. Crude Petroleum	Pounds Am. Sulf. per Ton
Sawmill brook No. 1	9.7	11.6	0.906	19.5
" " No. 2	8.9	10.7	0.893	33.8
" " No. 3	8.9	10.7	..	30.2
" " No. 4	20.4	24.5	..	30.2

Certain of the outcrops represented by the above analyses are of considerable thickness and extent. Although the analyses quoted do not indicate the presence of bodies of high grade shales, yet conditions on Sawmill brook appear to warrant further investigation.

Cape Breton

Shales, slightly bituminous in character, are exposed near Lake Ainslie and about the west shore of McAdam lake. None of these shales appear to have commercial value.

Province of New Brunswick

Of the oil shales of Canada, the most important are those which occur in the province of New Brunswick. This statement is based on incomplete data available at the present time. The oil shales constitute a part of the Albert Shale series, the geological position of which is shown in the following ascending section.

Palaeozoic	Carboniferous	Millstone Grit (gray and purple tinted shales, sandstones and conglomerates).
		—slight unconformity—
		Lower Carboniferous (gypsum, limestones, marls, shales, sandstones and conglomerates, generally red or green in color).
		—unconformity—
Pre-Cambrian		Albert Series (black, brown and gray oil shales with numerous sandstone beds; grits and conglomerates).
		—unconformity—
		(Slate, schist, diorite and granite).

Although the boundaries of the Albert shale series have not been accurately defined, the series constitutes a belt which may be traced through a distance of some seventy miles, from the Memramcook river on the east, to within a short distance of the village of Hampton. It is evident that the series extends still farther westward, since it may be readily recognized in the gray and black shales associated with the gray and brown sandstones exposed on Kennebecasis Island, a few miles north of the city of St. John.

In many places the rocks of the series are concealed by drift and by unconformable lower carboniferous sediments, but as a result of folding, the shales reappear at a number of points along the general line of strike. In passing westward, the bituminous character of the shales becomes less marked.

The northern boundary of the Albert shale series has not been accurately defined. To the west of Albert Mines the shales dip away from the Caledonia mountains at various angles. Some six miles to the north, in the Stony Creek oil and gas field, the series approaches the surface in the form of a structural terrace. North of the Stony Creek field the structure is obscure, but it appears that the steeply inclined shales of Indian Mountain, 7 miles north of Moncton, also belong to the Albert shale series, and represent the northern denuded limb of a broad syncline. Between the three points, the Albert series is entirely obscured by Lower and Middle Carboniferous sediments.

The principal areas, within which oil shales of commercial value have been recognized, lie within the counties of Albert and Westmoreland, and their approximate position is indicated on the geological and topographical maps issued by the Geological Survey of Canada. The actual aerial extent of workable beds of oil shale has not been determined, but outcrops of shale of commercial quality have been recognized near Upper Dorchester, Taylor Village (or "Taylorville"), St. Joseph's College, Albert Mines, Rosevale P. O., Pleasant Vale, Mapleton, and near Cata-

mount Station, and also along Downing creek, Frederick brook, East and West branches Turtle creek, Hayward brook, Prosser brook and Montgomery brook. It will thus be seen that the area underlaid by oil shale of commercial value, is of very considerable extent. At a number of localities, notably at Taylor Village, Albert Mines, Baltimore, Rosevale, and along the east and west branches of Turtle creek, beds of shale have been prospected to some extent by means of test pits and tunnels (Can. Dept. Mines, Report 1107). As a result of this work, it is evident that, at each of the localities noted, a number of oil shale bands of good quality and of workable thickness occur. Owing, however, chiefly to the effects of faulting and the prevalence of overburden, it is as yet impossible to indicate definitely the number and average thickness of such bands. This is particularly true of the Albert Mines area. In this area a great thickness of so-called "paper shales" apparently exists, but owing to complex distortion of the rocks, through faulting and folding, definite pronouncement regarding possible tonnage commercially available, must await further underground exploration.

Apart from surface indications, considerable additional information has been secured through the drilling of numerous deep wells. During the period 1899-1906, a local organization known as the New Brunswick Petroleum Company drilled upwards of 80 wells, chiefly in Westmoreland county between the Petitcodiac and Memramcook rivers. The majority of these wells were comparatively shallow, varying in depth up to 1100 feet, although one at least reached a depth of more than 3000 feet. In a number of these wells, small showings of petroleum were encountered, but the writer has no definite information regarding the number or character of the oil shale bands passed through.

Since 1909, Maritime Oilfields, Ltd., succeeded by its subsidiary, New Brunswick Oil and Gas Fields, Ltd., has successfully carried on an extensive drilling program in the Stony Creek oil and gas field, 9 miles south of Moncton, and elsewhere. The wells in the Stony Creek field are located on a structural terrace, and vary in depth from 1800 to 3200 feet. Their aggregate shut in capacity has exceeded 100,000,000 cubic feet of gas per 24 hours. The gas is found in a large number of interbedded sandstones, ranging in thickness up to 100 feet, and grouped along indefinite horizons through a vertical range of 2000 feet.

More recently, drilling to the dip of this gas area, has resulted in a moderate production of high quality paraffin base petroleum, and during 1920 the year's production exceeded 6300 barrels. The greatest thickness of the Albert shale series recorded by any log from the Stony Creek field, is approximately 2800 feet, and in this log the occurrence of some 16 oil shale bands is noted. Of these it is considered that six bands, with an aggregate thickness of 72 feet, are of commercial quality, while the

remainder, aggregating in thickness 123 feet, are of somewhat poor quality. Interbedded with these oil shale bands are numerous other sandy, marly and limey shales and thin limestones, which show wide variation in thickness, character and texture. The total original thickness of the Albert shale series, estimated to be not less than 7000 feet, would doubtless include a much larger number of oil shale bands of commercial grade. It is considered that the richer bands of oil shale occur in the lower horizons of the series.

Owing to lateral variation, however, it has been found that, even when the horizontal distance between individual wells does not exceed 1000 feet, serious difficulty exists in correlating individual beds recorded in the logs. This appears to indicate that, in parts of the field at least, rapid changes in thickness and in character of oil shale bands and associated strata, may be anticipated. This tendency is in conformity with the habit of associated sandstones and shales of the Carboniferous series of eastern New Brunswick, many of which were laid down in basins of limited extent.

Between 1911-13, other private interests, said to be identified with Sir Wm. Mackenzie, tested the area along the southern margin of the Albert shale basin, by means of diamond drills. It is said that upwards of 14 holes, varying in depth from 700 to 1500 feet, were drilled in the vicinity of Rosevale P. O., between the east and west branches of Turtle creek, while upwards of 10 other holes were drilled at scattered points. During the period 1919-21, eight other exploratory wells, some of which reached a depth of more than 3000 feet, have been drilled in other parts of the Carboniferous basin of Eastern New Brunswick, by the D'Arcy Exploration Company.

Throughout the geological basin occupied by the Albert shale series, notable erosion has taken place. In parts of the basin, several thousands of feet of the series have been removed, and subsequently replaced by unconformable beds of middle and lower Carboniferous age. Obviously, under such conditions, only extensive and systematic drilling will indicate the extent to which associated oil shale bands have been affected.

Oil shale bands, associated with the Albert shale series, vary in thickness from a few inches to more than 25 feet. In most instances the shale kindles readily and burns freely. Small splinters, when ignited by a match, frequently support combustion for considerable periods. In general, the oil shales weather through various shales of gray, but the color of freshly broken surfaces ranges from gray to a typical chocolate brown or brownish black. The shales frequently contain thin laminae or partings of asphaltic bitumen resembling albertite.

In point of geological age, and in certain other respects, the oil shales of New Brunswick correspond somewhat closely with those of Scotland.

In each instance two general types of oil shale are recognized, viz., plain and curly. A sub-variety, usually referred to as "paper shale," is apparently a weathered form of plain oil shale. It is thin bedded, or papyraceous, separating readily into thin, flexible sheets of considerable surface dimensions. In many instances, the surface of the sheets are almost covered with imprints of fossil fish remains. Plain oil shales are usually flat-surfaced, showing more or less well defined lamination. On the other hand, curly shale usually occurs as massive bands, somewhat curled and contorted. It is very tough, breaks with a conchoidal fracture, and is usually especially rich in hydrocarbons, a condition which may have rendered it more easily crumpled than poorer grades of shale. As a rule, the New Brunswick shales are free from grit, and, although easily cut with a knife, do not yield thin, somewhat flexible shavings as do the Scottish shales.

In view of the similarity between the oil shales of Scotland and those of New Brunswick, each may probably be attributed to a somewhat similar origin. In both countries there is little in the shale which is soluble in benzine, carbon disulfide, ether and other similar solvents, and it would therefore appear that liquid hydrocarbons derived by destructive distillation, may be attributed to matter of organic origin [202], [1101]. To express this carbonaceous substance, the term "kerogen" has been suggested.

Apparently, material from which the shale beds were derived was originally deposited in the form of fine clays on the bottom of lagoons and swamps. If the theory of Steuart is accepted, there was associated with these sediments, vegetable matter converted into a pulp as a result of maceration and microbe action in water; richer materials of many kinds, such as spores, and a proportion of animal matter. We may, therefore, conclude that the origin of the kerogen in the shales, may be traced to fermentation and decomposition of organic matter, through microbe action. In certain cases such action may have been intensified by heat.

The present state of development of the New Brunswick oil shales may be briefly referred to. Attention was first directed to the possible economic importance of the oil shales of New Brunswick about 1849, when Dr. A. Gesner, a local geologist of marked ability, discovered on Frederick's brook in Albert county, a valuable deposit of the mineral which subsequently became known as albertite. Some fifteen years later,—apparently between the years 1860-64,—a number of the oil shale beds were examined, and at Baltimore, in Albert county, a retort and stills were erected. At this plant several thousand tons of shale were treated, the crude oil thus produced being subsequently refined and used generally throughout New Brunswick and Nova Scotia. Following

the discovery of free petroleum in Ontario and the United States, operations at Baltimore ceased, and it was not until 1908 that the question of retorting New Brunswick shale was again taken up seriously by the Albertite, Oilite and Cannel Coal Company of New York. In that year, a trial shipment of some forty-five tons of oil shale was mined by the company from the George Irving seam, which outcrops near Baltimore, and shipped to the oil shale works of the Pumpherston Oil Company, Limited, at Midcalder, in Scotland. In view of the importance that would attach to results of retorting this trial shipment, the company interested requested that the work be placed under government supervision. Accordingly, Dr. R. W. Ells of the Geological Survey of Canada, and Mr. W. A. Hamor on behalf of the company, were commissioned to proceed to Scotland. The results of their observations, embodied in a joint report issued by the Canadian Department of Mines in 1909 (Nos. 55 and 1107), were entirely favorable. Various considerations, however, quite apart from the actual merit of the New Brunswick shale deposits, and the subsequent outbreak of war in 1914, prevented commercial development at that time.

Representatives of the D'Arcy Exploration Company made a detailed examination of certain portions of the area. In connection with this work, a small retort of the Wallace type, with the necessary condenser, scrubber, pumps, etc., was installed on the west branch of Turtle Creek, two miles west of Rosevale Post Office. The retort had a charged capacity of approximately 100 lbs. Oil shale and derived distillation products were examined and analyzed in a laboratory erected in the immediate vicinity. No figures indicative of results of the work undertaken are available.

Detailed exploration of deposits of oil shale on Indian Mountain, some 9 miles northwest of Moncton, is also contemplated by a local syndicate.

In view of the incompleteness of data at present available, it is difficult to indicate with assurance the probable economic importance that may ultimately attach to deposits of oil shale lying within the area under consideration. Quality of shale and conditions affecting mining operations will be controlling factors, since the development of successful retorting practice may be assumed.

As regards the quality of shale, results of practically all available analyses made by the Mines Branch of Canada are based on samples taken from the more highly bituminous outcropping bands, and the extent to which these results may be applicable over considerable areas is as yet undetermined. It is considered, however, that the following summarized analyses, represent fairly the various shale outcrops from which the samples have been taken.

Locality	Imp. Gals. of Crude Oil per Ton of 2000 Lbs.	U. S. Gals. Crude Oil per Ton	Sp. Gr.	Pounds of Ammonium Sulfate per Ton
Shale retorted in Scotland	35.5	42.6	0.920	69
George Irving's seam	35.0	42.0	0.895	68
Baizley farm, Baltimore	48.2	57.8	0.895	98
E. Stevens farm, Baltimore..	43.8	52.5	0.892	60
Hayward brook—branch of Prosser brook	26.8	32.1	0.895	67
Sample (85 lbs.) from Baltimore run in 1907	45.5	54.6	0.910	100
Albert Mines:				
Sample No. 1	43.2	51.8	0.898	74
Sample No. 2	34.8	41.8	0.892	54
Sample No. 3	40.6	48.7	0.891	43
Sample No. 4	39.0	46.8	0.896	51
Sample No. 5	25.2	30.2	0.895	44
Albertite:	100.0	120.0	0.857	58
Three samples of the thin-bedded or "paper" shale	30.0	36.0	....	42
from Albert mines gave	16.2	19.4	....	36
	36.5	43.8	0.892	36
Turtle creek, west branch, gray shale	50.5	60.6	0.891	27
Taylorville Shale:				
Adams farm No. 1	37.8	45.3	0.897	86
Adams farm No. 2	42.5	51.0	0.901	79
Taylor's farm No. 1.....	42.0	50.4	0.902	76
Taylor's farm No. 2.....	40.2	48.2	0.903	90
Downing's Creek	24.2	29.0	....	26

It will be seen from the above analyses of samples taken over a wide area, that in the aggregate there is, in the counties of Albert and Westmoreland, a very large tonnage of valuable oil shale. The problem of extensive commercial development therefore becomes largely one of mining.

In considering the important question of mining, open cut methods have been suggested, and may be found applicable within certain limited areas adjacent to outcrops. But, throughout the greater part of the area, conditions will probably imply the adoption of some recognized underground system, or systems, of selective mining, approximating those employed in the winning of coal. The principal factors which will affect mining operations are variation in thickness and in quality of oil shale bands; variation in character of associated strata; effects of major and minor folding and of faulting, and the possible presence of natural gas. Such considerations indicate the necessity of adequate underground exploration, as a preliminary to commercial development.

Transportation in Albert and Westmoreland counties presents no serious difficulty. No part of the area is distant more than 12 miles from standard gauge railway, and branch lines can be constructed at reasonable

cost. Much of the eastern portion of the area is immediately adjacent to tide-water.

In certain other respects, conditions may also be considered as favorable. The country is well watered, and abundant fresh water is available. A natural gas field has been developed within the area. Climatic conditions are not severe.

Province of Quebec

Apart from certain deposits of oil shale in the Gaspé peninsula, no other occurrences have been recognized as yet in the province of Quebec.

The presence of oil shale in the Gaspé peninsula was reported (Geology of Canada) by Sir Wm. Logan in 1863, but until recent years no definite information has been available regarding the possible economic importance of these deposits. In the course of a brief examination in 1909, during which an area of some three hundred square miles was traversed by the writer, a number of oil bearing shaley sandstone bands were found and carefully examined. A number of samples, secured principally from outcrops along the St. John and York rivers, were subsequently tested in the laboratory.

The shales of the district, while of the same general horizon as those of New Brunswick and Nova Scotia, differ in marked degree in their physical characteristics. In the shales of New Brunswick and Nova Scotia, the hydrocarbons must be recovered by means of destructive distillation. In the case of shales examined along the York and St. John rivers, the hydrocarbon content appears in the form of thin black or amber brown laminae, and fragments of a resinous substance. The thickness of these laminae and fragments rarely exceeds one-eighth of an inch and is generally much less. The substance has a resinous lustre, conchoidal fracture, and is insoluble in alcohol or naphtha. It is scarcely fusible, but at high temperatures gives off abundance of inflammable vapor.

The following analyses probably indicate fairly well the content of much of this shale in crude oil and in ammonium sulfate per ton of 2000 pounds.

Locality	Crude Oil in Imperial Gals.	Crude Oil U.S. Gals.	Ammonium Sulfate Lbs. per Ton
St. John River	30	36.0	40
" " "	31.5	37.8	42.2
York "	20	24.0	22
York "	36	43.2	59.5

In so far as these analyses furnish any indication, the shales should be rich enough to warrant further examination. Judging, however, from

the limited extent as well as the irregularity of the majority of the outcrops examined, the presence of workable seams of commercial importance may be considered as somewhat doubtful.

Other shales, in the Canton of Port Daniel, appear to have little commercial value.

Province of Ontario

(*a*) South Western Ontario.

The occurrence of dark, fissile bituminous shales has long been recognized at various points in south western Ontario, notably on the Indian Reserve at Kettle Point, Lambton county, along the Sydenham river, near Collingwood, and elsewhere. They underlie a considerable area but, owing to the prevalence of heavy drift, their boundaries have not been definitely defined.

Geologically these shales are correlated with the Ohio shale of northern Ohio, and have been described by T. Sterry Hunt, Alexander Murray, Sir William Logan, E. M. Kindle, M. Y. Williams and C. R. Stauffer.

In 1859, twenty-four longitudinal cast-iron retorts, having a daily throughput capacity of from thirty to thirty-six tons of shale were erected near the town of Collingwood, and an attempt made to recover petroleum by distillation. It is stated that this quantity of shale yielded some two hundred and fifty gallons of crude oil, equivalent to about three per cent of the rock treated. It appears that, in the operation of these retorts, a certain degree of success was achieved, but operations ceased about 1861 following the discovery of free petroleum near Enniskillen.

The area underlaid by Ohio shales was not visited by the writer, but it appears that the shales, as a whole, are of little present economic importance. Analyses of two samples received by M. Y. Williams indicate a yield of approximately 10 pounds of ammonium sulfate and 10 Imperial gallons crude oil per ton. Analyses of other samples taken from outcrops near Alvinston and Shetland, indicate a yield of crude oil equivalent to 3 to 4 Imperial gallons and 6 pounds of ammonium sulfate per ton. Nine other samples of shale, said to be from south western Ontario (exact localities not stated), have also been tested at the chemical laboratory of the Mines Branch, Department of Mines, Ottawa. These showed an average yield of crude oil equivalent to 7.8 Imperial gallons (9.3 U. S. gallons), and 20.6 pounds of ammonium sulfate per ton of shale. The extent of the deposit of Ohio shale is estimated by Williams at 116,000,000,000 tons.

(*b*) Northern Ontario.

A broad, and generally level, sedimentary basin, frequently referred to as the James Bay coastal plain, extends south and south west from

the shores of James Bay. This basin is underlaid by rocks of Palaeozoic age, and is terminated toward the south and southwest by an escarpment of pre-Cambrian rocks. The area is traversed by a number of large streams, notably the Abitibi, Mattagami and Missinaibi. Along these Palaeozoic sections, including strata of Ordovician, Silurian and Devonian age are exposed.

The possibility of discovering free petroleum in Palaeozoic rocks of the James Bay coastal plain has recently drawn attention to certain petroliferous shales which outcrop on the Abitibi and Mattagami rivers. These shales, which belong to the Ohio formation, are well exposed at the Long rapids on the Abitibi river, and to a limited extent above the Long rapids on the Mattagami river. Sections exposed along the Abitibi are marked by a series of low folds, the general strike of which is approximately east and west. The maximum thickness of shale observed at any point was approximately 55 feet.

In 1911 (James Bay Surveys) these shales were examined by the writer and samples subsequently tested in the laboratory showed a yield of petroleum ranging from 7 to 16 Imperial gallons per long ton. The maximum yield of ammonium sulfate was equivalent to 16 pounds per long ton of shale. Partial analyses of three other samples, collected by Dr. M. Y. Williams, indicated a yield of from 3.5 to 12 Imperial gallons (4.2 to 14.4 U. S. gallons) crude oil per ton of shale. The calculated yield of ammonium sulfate, based on the nitrogen content, was equivalent to from 18.8 to 38.6 pounds per ton. The amount recoverable in actual commercial practice would be considerably less.

Provinces of Manitoba and Saskatchewan

(NOTE: During the field season of 1921, the writer undertook a reconnaissance with a view to determining the probable economic importance of the Cretaceous shales of the Pasquia Hills, Porcupine, Duck and Riding Mountains. A detailed report embodying the results of this work will be found in Mines Branch Publication No. 588.)

During recent years, attention has been directed to reported occurrences of oil shales of Cretaceous age in the provinces of Manitoba and Saskatchewan. Forty-one samples of the shales, representative of a wide area, were collected by the writer during the field season of 1921, and were subsequently tested in the laboratory. The maximum yield of crude oil from any sample was 12.8 Imperial gallons (15.4 U. S. gallons), while the maximum yield of ammonium sulfate was equivalent to 3 pounds per ton of shale. The specific gravity of the crude oil varies from .944 to .984. All shales examined carry a high percentage of water, the average content of 15 samples being equivalent to 15.4 Imperial gallons (18.4 U. S. gallons) per ton.

It appears, therefore, that shales examined in the provinces of Manitoba and Saskatchewan are of little present economic importance as a possible source of petroleum of ammonium sulfate. Should conditions at any time warrant commercial development, open cut mining could be undertaken in many areas under favorable conditions. Over very considerable areas, shales examined are covered by a comparatively light overburden, consisting chiefly of boulder clays and gravel, which could be readily removed by hydraulic methods.

Province of British Columbia

The occurrence of oil shales has been reported near Harper's Camp in the Cariboo District, near Lytton, and along Calder Creek, a tributary of Flathead river. Detailed exploration of these occurrences has not been undertaken, but from present information it appears that the maximum yield of crude oil from any sample tested does not exceed seven Imperial gallons per ton.

On Graham island, the most northerly of the Queen Charlotte group, viscous hydrocarbons have a wide distribution throughout sedimentary and intrusive rocks of Cenozoic and Mesozoic age. Semi-fluid bitumen is seen as thin films along bedding planes and joint surfaces, as veinlets in various fractured rocks, and in amygdules of certain basalts,—as at Tian Point. This condition was observed by the writer in 1905 and has subsequently been fully described by J. D. Mackenzie in a report dealing with the geology of Graham island.

The presence of traces of bitumen over a wide area on Graham Island was, at one time, interpreted as a possible indication of petroleum pools. Mackenzie considers that the bitumen originates in the Maude formation,—a series of dark colored, fine grained, thinly laminated and highly fossiliferous argellites, of lower Jurassic age. He considers that the possibility of discovering commercial pools of petroleum associated with sediments of Graham island, may be regarded as remote, but suggests the possibility that oil shale bands of commercial value may be found associated with the Maude formation.

Provisional District of Mackenzie

From time to time, during the past thirty years, the occurrence of oil shale has been reported along the Mackenzie river between Fort Norman and Fort Good Hope. These shales are associated with rocks of Devonian age, but little information is as yet available regarding their thickness, extent and value as a possible source of petroleum and various by-products. The outcrops occur some 1500 miles to the north of the

city of Edmonton, the nearest large centre of population, and, apart from other considerations, the geographical position thus renders them of little present economic importance.

Provisional District of Franklin

Among the specimens collected by Captain Bernier during the voyage of the S.S. "Arctic" in 1908 were black oil shales which were picked up on the beach of Melville island. These specimens are rich in hydrocarbons, kindling readily when ignited by a match. They are apparently of the same class and probably of the same horizon as the oil shales of New Brunswick, Newfoundland, and Bear island, Spitzbergen.

The results of a sample determined in the laboratory of the Canadian Mines Branch showed 64 pounds of ammonium sulfate and 140 Imperial gallons of crude oil per ton of shale.

Conclusion

Certain of the oil shale deposits of Canada thoroughly warrant careful investigation. These deposits represent a large aggregate tonnage of valuable shale, and there is good reason to suppose that, under reasonably favorable conditions, they will eventually prove of sufficient merit to constitute the basis of a large and lucrative industry.

Commercial development of these deposits will be determined by the question of supply and demand, for it may be assumed that efficient retorts, adapted to the treatment of various types of shale, will be developed. Apparently mining charges will constitute the most important single factor in production costs, and for the immediate present will adversely affect development. Exceptional instances may exist where shales carry reasonably high values, and where conditions affecting mining operations are unusually favorable.

Should conditions not appear favorable to commercial development in the immediate future, certain of the oil shale deposits of Canada should, nevertheless, be regarded as constituting potentially a valuable national asset.

Newfoundland

Oil shales occur in several parts of the island.[299] One large deposit underlies the city of St. John's and another occurs on the western shore of White Bay. The largest and most promising runs north from Deer and Grand lakes to the head of White Bay. This may possibly be connected with outcrops reported on Notre Dame Bay. The shale is iden-

tical in geological features and oil content with those of Nova Scotia and Cape Breton island. The deposits cover 750 square miles, have a thickness ranging from 50 to 100 feet and an average oil yield of between 35 and 50 gallons per ton.

It is reported that the oil contains a rather rare asphaltic material which is much in demand.

In one large area [248] the Newfoundland shale is impregnated with ordinary petroleum, and, as a consequence, yields an oil somewhat different from true shale oil. Samples of this indicate a possible yield of 40 gallons or more per ton.

UNITED STATES

By R. D. George

Previous to the discovery of well oil in Pennsylvania there were fifty or sixty plants in the United States and several in Canada distilling oil from black shales and low grade cannel and other coal. According to Redwood [212] these plants were distributed as follows:

One in Portland, one in New Bedford, four in Boston, one in Hartford, five in the environs of New York, eight or ten in western Pennsylvania, twenty-five in Ohio, eight in Virginia, six in Kentucky, and one in St. Louis.

An examination of the shales at some of the localities in which these plants were located shows that they operated on rock which carried only 4 to 10 per cent of volatile matter, and which, therefore, would yield only 8 to 20 gallons of oil per ton. It is probable that nearly every state in the Union has considerable bodies of shale of equal grade. But under present conditions such shales cannot be classed as commercial possibilities.

The deposits which, by reason of their geographical position and their high kerogen content, are of most immediate promise are those of Colorado, Utah, Wyoming and California. The character of the deposits near Elko, Nevada, is a matter of dispute. Some writers believe they are true oil shales, while others hold that they owe their oil yield to seepage from true oil reservoirs, and cannot be classed as oil shales.

Eastern United States

The work of Ashley of the United States Geological Survey (Bull. *641,* 311 of 1916) shows that east of Mississippi river oil-bearing black shales exist in very great volume and are widely distributed. They occur mainly in the Ordovician, Devonian and Carboniferous systems, from New York to Alabama and westward to the Mississippi River.

The most important body of black shale is the Chattanooga, New Albany, or Ohio shale of Devonian age. This bed underlies the eastern coal fields and crops out in a long line from central Alabama northeastward through Tennessee and Virginia, and all around the Nashville Basin, in central Tennessee. West of the Appalachian coal field its outcrop extends from north to south across central Ohio, thence through central Kentucky to Louisville, from which it stretches in a broad belt northwestward across Indiana nearly to Chicago. From this western belt of outcrop the shale extends eastward under eastern Ohio and underlies nearly all of Kentucky and all of Indiana west of the outcrop.

The logs of 17 oil wells in fifteen counties of Indiana show that the New Albany shale ranges from 65 to 147 feet in thickness, and averages 105 feet.

Summary of the Results of Tests Made for Ashley

State	No. of Samples	Average Rate of Yield per Ton
Indiana	8	7.33 gallons
Illinois	2	13.95 "
Kentucky	3	8.4 "
Ohio	4	7.07 "
Pennsylvania	7	27.47 "
Tennessee	13	5.2 "
West Virginia	5	2.8 "

The average oil yield of the 42 samples of shale tested was .10.5 gallons per ton, and 6 yielded as much as 20 gallons of oil per ton. The average ammonia yield was very low. The 6 samples exceeding 20 gallons per ton were shales associated with coal seams, and 4 of them are classed as cannel shale or cannel coal.

Indiana

The richer parts of the Ohio shales are dark bluish black, and give out a distinct oily odor when broken. They weather to a gray color. At New Albany the shale is 100 feet thick, and 5 samples taken from the outcrop averaged 8.1 gallons per ton. Of 3 samples from strata immediately overlying a coal seam near Boonville, two ran 14 gallons or over per ton. The third was barren.

The logs of 17 wells in 15 counties of Indiana show that the New Albany (Ohio) shale ranges from 65 to 147 feet in thickness, and averages 105 feet. The depth to the shale ranges from 5 feet to 1,044 feet and averages 330 feet. The shale underlies 16,000 square miles in southwestern Indiana, and it may be assumed that the oil-yielding strata are

30 feet thick. One-half of this, or 15 feet is perhaps recoverable with an average yield of 10 gallons per ton.

The shales yield a satisfactory illuminating gas, and by certain methods of distillation oil of high grade can be obtained.

Kentucky

The Kentucky Geological Survey [818] has reported briefly on the oil shales of the Pottsville (Pennsylvanian), the Waverly (Mississippian), and the Ohio (Devonian) of that state. The Pottsville shale beds are too thin to be of immediate commercial importance, but those of the Waverly and Ohio formations are more promising. The area of outcrop of Ohio shale is probably over 1000 square miles. Laboratory tests indicate that the oil yield of the Ohio shales may reach 8 to 28 gallons per short ton.

Western United States

Montana

Oil shales occur in the Permian and Tertiary strata of Beaverhead county, Montana [851, 437]. The Permian shales near Dell and Dillon form beds of 3 feet or more in thickness which yield 25 to 30 gallons of oil per ton. The Tertiary oil shales do not appear to be of any commercial promise.

Tennessee

The Ohio (Chattanooga) shale underlies nearly all the upland region of middle Tennessee. It outcrops at the foot of the escarpment east of the coal field and near the foot of the escarpment facing the Nashville Basin. West of the Nashville Basin and along Tennessee River are many areas where the black shale underlies gentle slopes.

Numerous samples tested gave a fairly uniform yield of 6 gallons per ton.

West Virginia

Five samples from the Onondaga member of the Romney shale, of Middle Devonian age, at a locality well east of the coal fields, in what has been called the Appalachian Valley, yielded at the rate of 6 gallons per ton. The samples were from closely folded strata, and may not be a fair test of the possibilities of the shale as a whole.

Though of much lower grade than the great masses of oil shale of Colorado, Utah and Wyoming, the eastern shales have certain advantages which may offset, in part, the smaller yield. They are nearer the centers

of industry and population, are soft and will be more easily mined than the western shales, are nearer to transportation, and are believed to yield a higher grade of crude oil. The Permian shales are in the Phosphoria formation, and the most promising occurrences known are those of Muddy Creek basin and Smallhorn Canyon. The shale is dark brown to black, locally oölitic, and commonly phosphatic. It burns freely, and in most localities gives a petroleum odor when rubbed.

The Phosphoria formation is widely distributed, but oil shales of commercial promise are known only near Dell and Dillon.

In the western part of Meagher county a small body of shale yielding at the rate of 30 gallons per ton occurs in the Quadrant formation (Mississippian and Pennsylvanian).

The Tertiary oil shales of Muddy Creek basin contain layers 5 feet thick which yield oil at the rate of 24 gallons to the ton. The area of such shale is small.

Nebraska

A sample of shale, said to have come from the Cretaceous of southern Nebraska, tested by the writer, yielded over 40 gallons of oil per ton, and the sender of the sample is authority for the statement that a large body of such shale exists in that part of the state.

Texas and New Mexico

Oil shale deposits occur in Texas and New Mexico, but the information concerning them is meager and uncertain.

Colorado, Utah and Wyoming

The oil shales of the Green river formation [1116, 1118] occur in Garfield, Mesa and Rio Blanco counties of northwestern Colorado; in Uinta, Sweetwater and Lincoln counties of southwestern Wyoming; and in Uinta, Duchesne, Carbon and Wasatch counties of northeastern Utah. Of these deposits, the largest now known is in Utah.

In Eocene time a vast lake basin occupied the northwest corner of Colorado, the southwest corner of Wyoming and the northeast corner of Utah. To the south of this basin in Utah and separated from it was another lesser, but still large, lake basin in Tertiary time. From the sediments carried into these basins were built up the Wasatch, the Green river, the Bridger and the Uinta formations, having a total thickness of several thousand feet.

During the deposition of the upper half of the Green river forma-

tion the geological conditions were, at times, favorable for the formation of oil shales, which occur in bands and strata ranging in thickness from a few inches to 75 or 80 feet. In many instances they are sharply set off from the underlying and overlying strata, while in others there is a gradual transition from rock practically free from bituminous matter to layers which will yield as high as 60 to 80 gallons of oil per ton,

Fig. 9.—Typical view Colorado and Utah rugged shale country.

and from this again to the almost barren rock above. Within the thicker oil shale bands the oil yield varies widely. Thin layers may be selected which will yield as high as 90 gallons per ton, and strata from 3 to 10 feet in thickness may be found which will average from 60 to 70 gallons per ton. Between these will be leaner strata ranging down to barrenness. The shales will also yield upwards of 20 pounds of ammonium sulfate per ton.

The oil shale differs widely in color, composition, specific gravity, hardness and brittleness.

The lean shales are commonly whitish gray to buff, and sometimes blue gray. As a rule, the lighter the color of the shale the greater is the proportion of very fine sand, while the darker the shale the greater the proportion of clay substance and organic remains. The richest shales range in color from a deep brownish mahogany to almost jet black on fresh surfaces.

A very little experience usually enables one to select the rich and discard the lean by the specific gravity of the material alone. The leaner rock has nearly the usual specific gravity of common shales, 2.4 to 2.7, while the richest ranges from 1.4 to 1.85.

Under the hammer, the leaner strata behave as do ordinary shales. The more silicious rock breaks with a smooth conchoidal fracture and is very brittle, while the richest is exceedingly tough and hard to break, especially in the direction of its structure. Across the bedding it breaks with a smooth conchoidal fracture, frequently exposing a delicate color banding of black and brownish black. The fresh fracture surfaces of the rich shale are silky or satiny in appearance. If such surfaces are scratched with a pointed instrument the mark left has a waxy surface, and the fine material formed along the scratch resembles a grayish wax, cohering in masses and not falling into powder. The stroke of the hammer on the rich shale yields a sound similar to that produced when a hard, heavy wood is struck.

Lamination due to original deposition is present in practically all the oil shale. In some it is so pronounced that weathering breaks the edges of the strata into a fan-like series of thin flexible plates. These are the paper shales. In others the laminae are less distinct and the weathering results in more blocky masses. It has been suggested that the papery lamination is characteristic of the richer shale, but there is little or no ground for this view, as there are both lean and rich paper shales and lean and rich massive shales. Some bands of massive shale have a rough, wavy, concentric or lens-like structure which seems to develop in beds which contain more than the average amount of iron sulfide. Small caverns and pockets filled with fine papery material and often highly charged with iron sulfate and other soluble salts occur at intervals along the outcropping faces of these wavy strata.

The pyrobitumen content has rendered the oil shales more resistant to the processes of weathering than are the enclosing barren clay shales and the softer sandstones. In consequence, the edges of the rich strata project beyond the general surface of the valley walls. Small fragments of oil shale are notably scarce in the debris and alluvium at the foot of the precipitous cliffs in which the oil shales outcrop, but large blocks

bounded by joint planes are common in the coarser talus. An examination of the exposed edges of the massive shale strata impresses one with the idea that, except for the breaking away of the larger joint blocks, the erosion of the shales must be quite largely a process of solution and disintegration into the extremely fine sand and clay particles which form the inorganic matrix in which the organic material is contained. By exactly what agencies the bituminous matter is removed in this process of disintegration it is impossible to say. But it is certain that the process of the removal of this material is slow and goes but slightly ahead of the separation and disappearance of the inorganic material. The removal of the bituminous matter from the richer shales leaves a

Fig. 10.—Thin-bedded oil shale near Watson, Utah.

grayish white layer over the surface, which, on unfractured blocks, ranges from a mere film to rarely more than one inch in thickness. Where the shale is finely laminated the weathering has penetrated to a greater depth. But weathering rarely diminishes the kerogen of the massive shale to a depth of more than 2 or 3 inches.

With the paper shales, however, weathering has opened up the fine layers and separated them in fan-like forms, into which the weathering agencies have penetrated for a considerable distance. But even in these, with rare exceptions of deep jointings, has the kerogen content been markedly reduced beyond 3 or 4 feet from the outer surface.

These great deposits of oil shale may be spoken of as an unfinished oil field. The shales, with their great content of organic matter, were laid down in horizontal position and large areas have remained but

slightly disturbed since the time of their formation. The whole series of rocks in which the shales occur consists of alternating layers of shale with little organic material, shale with much organic material, and sandstone with little or no organic remains. It is reasonable to suppose that if the oil shale area were subjected to great earth movements, compressing and folding the strata and arching them into anticlines, the heat and pressure developed as a result of such movements would cause the distillation of oil and gas from the organic remains. The oil and gas so formed would find their way into the porous sandstones and would be prevented from escaping by the overlying impervious shales. Under favorable structural conditions the oil and gas, being lighter than water, would travel through sandstone strata charged with ground water to the crests of the anticlines, the gas, oil and water would arrange themselves in the order of specific gravity in the anticline, and we should have a duplication of the commonest form of oil structure and the commonest condition of the occurrence of oil and gas.

As to the quantity of oil obtainable from the shales of Colorado, Utah and Wyoming: there can be little doubt that from workable beds of shales in Colorado alone there may be obtained ten times as much oil as has been produced in the United States since the discovery of petroleum in Pennsylvania in 1859. The areas underlain by oil shale in Utah and Wyoming are much larger than those in Colorado, however, the oil shale strata are generally thinner, and the kerogen content is generally lower. It is highly probable, however, that in each of these shales the oil possibilities of the workable shale beds are, in the total, as great, if not greater, than those of the Colorado deposits.

Nevada

The oil shales of Nevada, probably of Green river age, are mostly in the eastern district near Elko and Carlin. They differ physically and chemically from the shales of Utah, Colorado and Wyoming, are generally softer and characterized by their lighter color for the same yield of oil.

The Nevada shales generally lie in somewhat shallow basins of considerable extent. As a rule the beds are rather thin, dip steeply and are extensively faulted and folded. The richest seam thus far reported [1085] is about four feet thick; a sample across the face yielded 32 gallons of oil per ton and contained 0.43 per cent of nitrogen, equivalent to 40.5 pounds of ammonium sulfate per ton. The richest 2 feet of this seam yielded over 60 gallons of oil per ton. This bed dips at an angle of about 23 degrees and above and below it are much thicker beds of leaner shales.

California

The California "oil shales" are for the most part not true oil shales as most of the bituminous matter or oil in them can be extracted by suitable solvents. The most extensive deposits are part of the Monterey formation of Tertiary age and differ physically and chemically from the oil shales of Scotland and from those of other parts of the United States. The mineral matter of the shale is diatomaceous and the beds that yield oil occur in massive formation. They are softer than the other shales mentioned, not at all flexible, brown or brownish-yellow in color and when freshly broken smell strongly of petroleum. A heavy tar-like petroleum or asphalt often seeps from fissures and formation cracks in the beds. The oil yield of the shales varies greatly from place to place, but the average is not high. Some few deposits, however, yield up to 40 gallons of oil per ton and the richness seemingly increases with depth from the outcrop. The oil is usually high in sulfur and apparently difficult to refine. The nitrogen content of the shales is very low. In many places the deposits are thick and accessible, so, nothwithstanding the general low yield of oil, the shales have commercial possibilities.

SOUTH AMERICA

In South America, bituminous shales occur in several countries, but with the exception of those of Eastern Brazil on which Hartt [49], Redwood [93] and Branner [119] have reported, and some recent discoveries in Argentina, very little information is available as to their quality and extent.

Brazil

Oil shales are very widely distributed, both geologically and geographically [119, 428]. "They are found from the Permian to the Pliocene." The principal occurrences are those at the base of the Upper Permian, and those of the Tertiary freshwater deposits. They have been reported from: Maranhão, Ceará, Alagoas, Bahia, Minas Geraes, Rio de Janeiro, São Paulo, Paraná, Santa Catharina, Rio Grande do Sul and Goyaz.

Upper Permian strata form an almost continuous band from the northern part of Maranhão in S. latitude 3° to Torres in S. latitude 29°, in Rio Grande do Sul. At many points in this great area the basal beds of the Upper Permian are bituminous.

"The Permian rocks are sandstones, clay shales, and limestones cut in many places by eruptive dikes. For the most part they are horizontal, and they seem to be of land or fresh water origin, though what are

supposed to be brackish water fossils have been found in them." The oil shales appear to be especially well developed in Paraná and São Paulo where the Iraty black shale series of the basal part of the Upper Permian is widely exposed. Farther north the Permian rocks are not so certainly identified, but the following section given by Oliveira suggests the occurrence of the Iraty series with its oil shales at the base of the Upper Permian.

5. Ferruginous conglomerates and sandstones.
4. Clay shales.
3. Bituminous shales.
2. Limestones.
1. Shales at the base.

Tertiary formations skirt the greater part of the Brazilian coast. They range in age from Eocene to Pliocene. In origin they include freshwater or land deposits, brackish water deposits and marine sediments. "At several places in the states of Bahia and Alagoas the Tertiary beds include bituminous shales that may eventually be of economic importance." Bituminous shales also occur in the Tertiary of Minas Geraes and São Paulo.

At Taubaté the shales were used for the manufacture of gas. A large plant was installed at Marahu in Bahia for the manufacture of oils, soap and various other products, but, owing to mismanagement, it had to be abandoned.

One of the more important occurrences of oil shale is in the lower part of the Eocene, between a series of highly colored beds and the granitic conglomerate at the base of the Tertiary. The shales are commonly interbedded with sandstone and range in thickness from a few inches to several feet. A shaft 108 feet deep passes through four strata of bituminous shale, the thickest of which is 15 feet.

Redwood's tests of the shales at Camaragibe (Tertiary) showed a range of volatile matter from 7.8 to 30.55 per cent, and an average for five samples of 23.25 per cent. His test of the shales of Riacho Doce showed a volatile content ranging from 25.4 to 46.3 per cent, and an average of 33.26 per cent.

Peru

Oil-yielding shales occurring in or near some of the mining districts of Peru have been examined and tested with a view to their availability as a source of fuel for mining and smelting purposes. Samples from one of these deposits yielded 24 gallons per ton of a high quality of oil quite different from that yielded from other shales tested by

the writer. The geological features of the deposits have not been described. Argentina, Chile and Uruguay also contain deposits of oil shales, but their commercial possibilities are not yet known. A sample from Chile yielded oil at the rate of 28 gallons per ton.

AFRICA

Oil shales are reported to occur in various parts of Africa, including the South African Republic (Transvaal), Cape Colony, Natal, Basutoland, Griqualand East, Rhodesia, Mozambique and Madagascar.

Natal

Bituminous shales occur in comparatively thin strata closely associated with worked coal seams. The results of tests point to the probability that they are low grade coal and not true oil shales. However, when distilled at low temperatures, they gave a low yield of paraffin oil, but this is not inconsistent with the belief that they may be coal shales.

Very promising results have been obtained from the testing of oil shales from the southern part of the state.

South Africa

Oil shales of the South African Republic outcrop at various points in the Great Eastern Coal Field. The rocks containing the coal and the shale belong to the Karoo formation and are mainly coarse sandstones, and occasionally arenaceous shales. True clay shales are not found. The strata lie in horizontal position.

The principal oil shale deposits are in the Ermelo, the Wakkerstroom, the Middelburg and Utrecht districts. It is not known whether they underlie the intervening areas. The Wakkerstroom shales are much richer than those of the Ermelo district. The shale beds in both districts are thin seams associated with coal beds, and could be worked with the coal where the latter is of commercial thickness. The Ermelo shale yields 30 to 34 gallons of oil per ton. The Wakkerstroom shale runs as high as 90 gallons of oil per ton, but the seam is less than one foot thick.

Some writers contend that the Transvaal oil shales were impregnated with bituminous matter after their deposition. Others think they should be classed as impure coals and cannel shales, or torbanites.

The Stromberg Series of Cape Colony, Natal and Basutoland contains much carbonaceous matter, and it is reasonable to look for oil shale deposits in it.

ASIA

There can be little doubt that on a continent so largely covered by sedimentary rocks as is Asia, many deposits of oil shale will be found. Deposits are known in Mongolia, Kwang Tung, Manchuria, Siam, Burma, Arabia, Syria and Palestine.

Japan

Japan has diligently sought workable oil shales within her own territory but the search has not been successful. Lean "marine kerogen shales" are found above the oil sands in the oil fields of Japan, but they are below commercial grade.

The Japanese are developing the Fushun coal field of southern Manchuria. Above the coal are extensive beds of coaly shale and possibly true oil shale. The South Manchurian Railway is also an extensive miner of coal in southern Manchuria. The Japanese government and the Railway are planning a cooperative development of the shale resources which appear to be very promising.

Burma and Siam

A considerable deposit of workable oil shale occurs along the boundary line between Burma and Siam. The shales are said to yield at the rate of 30 to 45 gallons of oil per ton. They occur in Pliocene basins, and are of sufficient volume to justify development.

ASIA MINOR

Easily workable oil shale deposits of considerable size are known in Asia Minor. There is one deposit in Palestine which has as its inorganic component an impure limestone.

AUSTRALASIA

Oil shale and torbanite deposits have been worked in New South Wales, Queensland, Tasmania and New Zealand.

New South Wales

The kerosene shale deposits [134, 179] occur in detached areas just within the borders of the Permo-Carboniferous Coal Measures which form the coast line from Milton in St. Vincent County to Port Stephens in Glou-

cester County and extend north-north-westward to a point beyond the Liverpool Range.

Two of the areas described are on the eastern margin of the formation and all the others—forty or more—are near the western margin.

All but two of the deposits described are in the uppermost division of the Permo-Carboniferous. Those at Greta and Clyde River are in the Lower Coal Measures and nearly 8000 feet lower stratigraphically. The scarcity of known deposits in the lower measures may be due to the very limited outcropping of this part of the Permo-Carboniferous series. The shales of the upper series occur at several horizons in the Newcastle division of the Upper Coal Measures.

In many places the kerosene shales pass laterally into bituminous coal or coaly shale. In others they grade into ordinary clays. Strata of shale are also found between thin coal seams.

The shales resist weathering much more stubbornly than do the non-bituminous members of the same series, and the weathered edges of the strata sometimes show thin lamination. In a few places the poorer kerosene shales have weathered into a soft gray powder, a sample of which contained 18.18 per cent of volatile hydrocarbons. The powder from the richer shale is yellowish brown, owing to the abundance of the unaltered resinous-looking constituents.

In the matters of texture, fracture, luster, streak, specific gravity, response to the hammer and other physical characters the kerosene shale resembles the richer Colorado shales. The richest kerosene shales contain much more volatile matter than do those of Colorado.

Fossils are fairly abundant in the lower part of the shale. As mined the shale contains from 40 to 70 per cent of volatile hydrocarbons, but in the best it ranges from 57 to 77 per cent, and the oil yield is from 110 to 150 gallons per ton. The shale resembles cannel coal. The deposits rarely exceed one or two square miles in extent, and the seams run up to 5 feet in thickness.

The Commonwealth Oil Corporation has extensive works at Newnes, which were closed down in 1923, being unable to compete with imported petroleum.

Queensland

In Queensland [221], oil shales occur as follows:

1. On Curtis Island and the adjacent mainland are extensive deposits of workable shale of Tertiary age.

2. Rich shales, probably torbanitic in character, are found in Baffle Creek valley. They are probably of Tertiary age.

3. Shales are found in the Tertiary beds at Duaringa in the Leichardt District.

4. Kerosene shales similar to those of New South Wales are known on the Queensland slopes of McPherson Mountains.

Tasmania

The name tasmanite [130] has been given to a torbanitic shale of somewhat inferior quality occurring in the Lower Coal Measures of Permo-Carboniferous age on both sides of the Mersey River. The deposits have been developed.

The Tertiary beds of the Mersey River District near Latrobe, Nook Road and vicinity contain workable beds of oil shale.

New Zealand

Oil shales occur as small but very rich deposits in the upper portion of the Permo-Carboniferous Coal Measures, in D'Urville Island in Cook Strait; Mongonui and Waiapu in Auckland; Kaikora and Blueskin in Otago; and at Orepuki in Southland. Analysis from several of these deposits are comparable to those of the best kerosene shale of New South Wales.

A good variety of oil-yielding shale is obtained from the Chatham Islands, and a high grade shale occurs at Waimate, Bay of Islands.

Extensive treatment works were established at Orepuki, but they did not operate long.

CHAPTER 4

KEROGEN—THE OIL YIELDING MATERIAL OF OIL SHALES

By Ralph H. McKee and Ralph T. Goodwin

The word "kerogen" was first used by Professor Crum Brown to designate the oil yielding material of oil shales. Brown described kerogen as the material in Scottish shales which, on destructive distillation, yields oil. It is neither petroleum nor bitumen, but a substance (a pyrobitumen) yielding petroleum and nitrogenous compounds when it is distilled. An oil shale may then be defined as "a clay or argillaceous shale which contains kerogen." It is to be emphasized, however, that kerogen is not a definite chemical compound, but probably a complex mixture of complex compounds, and that the kerogens of different shales are dissimilar. The term is merely a convenient designation of the organic oil yielding material of oil shales.

A study of kerogen is complicated by the great difficulty of separating it from the mineral matter which forms the bulk of an oil shale and with which it is most intimately associated. The first study of kerogen was concentrated on the "Torbanhill mineral" of Scotland at the time of the famous Torbanhill law suit in 1854, when experts attempted to settle the question of whether the material known as "Torbanite" or "Boghead Mineral" was a coal or an oil shale. Several witnesses at the trial maintained that the oil yielding matter in the mineral was of organic origin, while others considered it to be bituminous and produced by subaqueous eruptions. Torbanite contains a much larger proportion of kerogen, yields much more oil than most oil shales and many investigators do not regard it as an oil shale.

The Chemical Composition of Oil Shale

Oil shales in different parts of the world and in different geological formations differ in both physical and chemical character. Table I [697] gives data as to ash analyses, volatile and fixed carbon percentages and oil yields of typical oil shales of the United States, and Table II [1017] gives ultimate analyses of typical oil shales and related materials from different parts of the world. These tables show the extent of variation between different shales.

TABLE I

ANALYSIS OF OIL SHALES FROM VARIOUS LOCALITIES

Source of Shale	Ash Analysis				Volatile Matter and Fixed Carbon	Oil Yield Gals. Per Ton
	SiO_2	Fe_2O_3 and Al_2O_3	CaO	MgO		
DeBeque, Colo	44.70	25.60	17.65	5.28	40.0%	42.7
Elko, Nev.	65.5	25.5	0.6	0.8	33.5	32.5
Dragon, Utah	45.8	16.4	23.9	7.9	42.2	41.6
Dragon, Utah	46.8	17.5	23.9	8.9	34.3	21.7
Green River, Wyo.	38.9	12.4	38.3	4.9	34.9	23.4
Green River, Wyo.	41.9	18.8	17.6	10.9	48.1	58.7
Kentucky	52.0	19.1	12.5	8.2	29.3	18.2
Ione, Calif.	43.0	38.1	8.7	2.5	62.9	52.0
Casmalia, Calif.	75.8	19.1	1.4	0.9	...	18.0

More experimental work has been done on Scottish shales than on shales from other parts of the world, but, because the character of oil shales varies so materially, results of studies on the Scottish shales probably will not generally apply to all shales. Thiessen [848] has reported that the shales of Kentucky, Ohio and Indiana are similar in character to the Scottish shales, but other investigators have shown that the prod-

Fig. 11.—Heat changes on retorting Colorado shale.

ucts yielded by them are not like those from the Scottish shales. Oil shales from different regions or geological formations yield oils of dissimilar character. The shale from Elko, Nevada, is characterized by yielding an oil containing a high percentage of paraffin wax; shales of Utah and Colorado yield an oil containing less wax and more asphaltic constituents, while the Devonian shales of the eastern part of the United States yield an oil containing only a very little wax.

Oil shales and the oils produced from them vary greatly in sulfur

content. Sulfur in coal is reported [1017] to be present in four characteristic forms, two of them organic and two inorganic. The only known sulfur compounds reported to have been found in oils fall into the following classes: (*a*) hydrogen sulfide, (*b*) carbon disulfide, (*c*) alkyl sulfide or thioethers, (*d*) thiophenes, (*e*) thiophanes, (*f*) mercaptans.

Franks [777] has made a study of the sulfur in a Colorado shale oil. The sulfur apparently was not present in any of the forms above mentioned, but rather occurred in forms suggesting an asphaltic nature and a very complex structure. Franks determined the amount of sulfur in the 10 per cent distillation fractions of a Colorado shale oil. The sulfur content was very low in the first (low boiling) fraction, reached a maximum in the second fraction, and then gradually reduced to a minimum in the highest boiling fractions. The rather constant amount of sulfur in the middle fractions of the oil indicated the presence of a series of isomers. A pronounced deflection in the sulfur curve for the lower frac-

TABLE II

CHEMICAL ANALYSIS OF OIL SHALES

General Results of Ultimate Analysis

Shale	C	H	N	S	O by Dif.	Ash	C/H Ratio	Oil Gals. Per Ton
Scottish (Broxburn) ..	19.51	2.48	0.69	1.36	3.31	72.65	7.86	23.3
Scottish (Pumpherston)	24.88	3.67	0.68	0.80	8.07	61.90	6.78	31.0
Australian (Commonwealth)	63.58	7.81	0.81	0.43	4.41	22.96	8.14	10.8
Utah (Soldiers Summit)	13.51	1.70	0.39	0.28	18.00	66.12	7.94	16.8
Nevada	37.65	5.43	0.39	1.08	10.04	46.21	7.24	86.8
(Elko)	8.61	1.44	0.48	1.12	6.76	81.59	5.98	8.4
Colorado (Grand Valley)	23.67	3.50	0.66	1.78	3.79	66.60	6.76	63.5
California (Ione)	50.95	5.77	0.42	2.12	18.06	22.68	8.83	51.8
Lignite (Black, U. S.).	54.91	6.39	1.02	...	32.54	5.14	8.59	...
Crude shale oil (Autun, France)	79.70	11.80	...	...	8.50	...	...	...
Crude petroleum (Penna. Heavy)	84.90	13.70	...	...	1.40	...	...	...
Crude petroleum (California) ..	84.00	12.70	1.70	0.75	1.20	...	...	...
Asphalt (Trinidad) ...	82.60	10.50	0.50	6.50	nil	...	...	...
Cannel Coal (English)	79.23	6.08	1.18	...	7.24	4.84	...	...

tions indicated a series of sulfur compounds different from those found in the heavier fractions.

The nitrogen content of oil shales appears to be present in several chemical forms (see Chapter 9). In retorting, a part of the nitrogen is evolved in the form of ammonia, pyridines, and isoquinolines at low

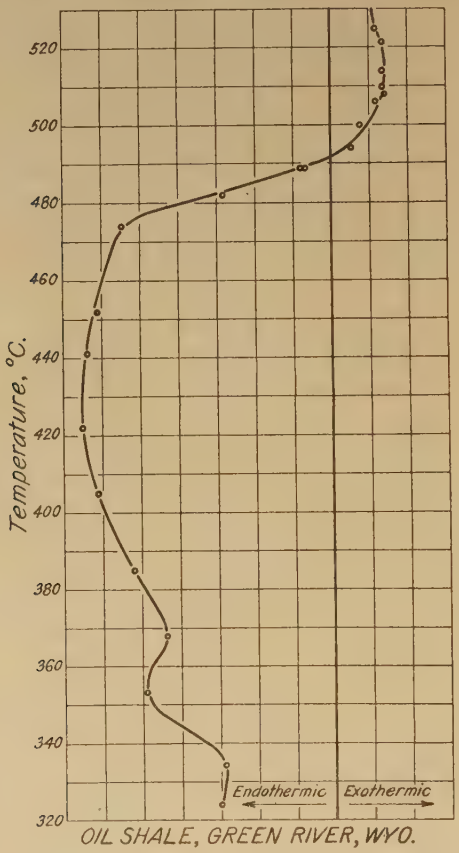

Fig. 12.—Heat changes on retorting Wyoming shale.

temperatures, but evolution of nitrogen compounds continues to higher temperatures. Ammonia yield is increased by the use of superheated steam and generally is so obtained at relatively high temperatures.

The authors have studied heat changes at different temperatures as oil is distilled from oil shale and found a surprising variation between different shales. With all shales, during the greater part of the distillation heat was absorbed, but at times the reaction was frequently

exothermic. Figures 11, 12 and 13 show the nature of the heat changes occurring during the distillation of a few oil. shales and a sample of lignite. About the only definite conclusion to be drawn from these

Fig. 13.—Heat changes on retorting lignite and ione, California shale.

curves is that commercial distillation procedure will have to be varied with the shale to be retorted and that no one method of retorting can be used equally well with all shales.

Cracking of the Oil during Retorting

The unusually high percentage of "unsaturated compounds" (compounds removed by treatment with concentrated—66° Bé.—sulfuric acid) in shale oil has been explained by the low hydrogen content of the oil forming matter of the shales. The kerogen does not contain enough

hydrogen to form saturated compounds of all the organic carbon of the shales.

Other writers have suggested that the high percentage of "unsaturated" constituents in shale oil is caused by the cracking of the oil in the retort, following its production from the kerogen. When petroleum is overheated or cracked, the products obtained have lower boiling points and higher percentages of unsaturated hydrocarbons than the oil from which they were made, and it has been assumed that shale oil acts in the same manner under the same conditions. To reduce cracking of shale oil during retorting, many have advocated retorting in a current of steam or under reduced pressure at the lowest practical temperature. [212, p. 52, 796]

The oil-yielding materials of oil shales differ in constitution and the manner of breaking down when undergoing destructive distillation. Differences in chemical constitution are shown by differences in ultimate analyses, by differences in solubilities in various solvents and by differences in reactions with chemical reagents. Different behavior during thermal decomposition is indicated by different decomposition temperatures and different products formed. Because of these variations each shale presents a somewhat different problem; when different shales are treated under similar conditions they yield products of different nature, and also the same shale will yield products of different character when it is retorted under different conditions. Thus the refining of shale oil really begins with retorting and the different behavior of different shales or the same shale under different retorting conditions indicates that conditions suitable for the production of satisfactory finished products from any one type of shale will not necessarily be the conditions suitable for making satisfactory products from any other shale. The satisfactory retort for one shale may not solve the retorting problems presented by other shales.

When an oil shale is distilled rapidly in a vacuum, a solid waxy material is obtained [1017]. This product is completely or nearly completely soluble in 66° Bé. sulfuric acid, and, accordingly, its "saturation" percentage is approximately zero. If this product is redistilled at atmospheric pressure there is evident decomposition and the distillate by the sulfuric acid test is about 50 per cent "saturated".

When oil shale is destructively distilled it is doubtful whether any of the final products, except possibly some of the gas, are liberated as such from the kerogen. The production of oil from the kerogen takes place in two stages. A primary decomposition occurs, in which the insoluble kerogen changes into a soluble solid, or semi-solid, bitumen. This intermediate product is not of the same composition as the kerogen, as indicated by its analysis and its ready solubility. This intermediate

bitumen is unstable and a second decomposition changes it into the lighter oils of greater stability and higher "saturation." Experimental work has shown that the stability, specific gravity, viscosity, volatility and "saturation" of the oil produced increase as the decomposition of the intermediate product increases. Both the primary and secondary decompositions are accompanied by a series of thermal reactions. The formation of oil from oil shale thus takes place as follows: kerogen—intermediate bitumen—shale oil.

The percentage of "saturates" of a shale oil is increased by distillation to coke at atmospheric pressure. Corresponding with this is an increase in the amount of low boiling fractions in the distillates. Evidence indicates (see Fig. 18) that crude shale oils produced from the retort at ordinary rates, are mixtures of secondary decomposition products and of undecomposed or only partly decomposed "intermediate bitumen" which has been carried from the retort with the gas and oil vapors during distillation. The increase in quality of a shale oil resulting from a redistillation of the crude oil may largely be explained by the decomposition of this undecomposed bitumen in the oil during the redistillation.

The decomposition or cracking of well petroleum under the influence of heat and pressure is accompanied by a change of products of high molecular weight into products of lower molecular weights. This cracking always decreases the amount of "saturates" in the lower boiling product formed. When a highly "unsaturated" shale oil is cracked, the results obtained are apparently just the reverse of those obtained with petroleum.

The cracking of well petroleum and shale oil petroleum are not entirely parallel processes, however. Well petroleum is ordinarily a mixture of a great number of hydrocarbons of different molecular weights and degrees of complexity. When these are heated, the least stable hydrocarbons—those of high molecular weight and great molecular complexity—break down into simpler forms, yielding both saturated and unsaturated hydrocarbons, the net result being that the cracked distillate is more or less unsaturated, i.e., really contains unsaturated hydrocarbons, whereas the original oil was practically completely saturated, i.e., contained no unsaturated hydrocarbons. A shale petroleum, on the other hand, contains saturated and unsaturated hydrocarbons, and in addition relatively large amounts of oxygen, nitrogen and sulfur compounds, which are not hydrocarbons but are measured as "unsaturates" by the sulfuric acid test. Some such shale oils contain over 10 per cent of basic nitrogen compounds which may be removed with quite dilute acid. When shale oil is cracked, undoubtedly some of the complex and heavy saturated hydrocarbons decompose to produce both saturated and

unsaturated hydrocarbons, and some of the complex unsaturated hydrocarbons break down to form both saturated and unsaturated hydrocarbons of simpler structure. Finally a part of the relatively unstable oxygen, sulfur and nitrogen compounds in the oil, which have been measured as "unsaturates," break down, yielding both saturated and unsaturated hydrocarbons, while the oxygen, nitrogen and sulfur may be eliminated to a greater or less extent. The net result is an indicated gain in "saturates" (insoluble in concentrated sulfuric acid). The gain is actual, but it is not alone because unsaturated hydrocarbons have been saturated or broken down to form simpler saturates during the cracking. A part of the gain is that compounds measured as "unsaturates" by test with a concentrated acid, are not all unsaturated hydrocarbons, but compounds which decompose on heating to yield "saturated" hydrocarbons. Distillation of shale under pressure (300 pounds per square inch) has been shown to increase cracking of the oil. If the process is carried out slowly the resulting distillate is as clear as water and of much lighter gravity than distillate from oil shale made at atmospheric pressure. Whether such a slow distillation at such a pressure could be carried out commercially is extremely doubtful.

The Action of Solvents on Oil Shales

The understanding of the composition of oil shale kerogen would be greatly advanced if any considerable part of it were found to be preferentially soluble in any given solvent. Little work of this nature has thus far been reported, however, and solubility studies apparently have shed little light on the composition of kerogens. Table III [914] gives the solubilities of a few typical oil shales in some of the common organic solvents, and shows that little of the organic matter of the shales can be obtained by extraction with these solvents. Different shales, however, show different solubilities, and this is another example of the fact that kerogens of different shales are not similar.

Experimental work thus far reported on the action of solvents and reagents on oil shales indicates that it will never be commercially feasible to produce oil from shales by extraction with organic solvents or by the action of chemical reagents of the ordinary type. This is to be expected as oil does not exist as such in true oil shales. Apparently the only practical method for the production of oil from oil shales is by the action of heat.

Action of Chlorine on Oil Shales

Hart (see Chem. Zeit., *30*, 1204 of 1906) has shown that chlorine, bromine and iodine are absorbed by different coals, thus indicating the

TABLE III

SOLUBILITY OF OIL SHALES IN VARIOUS SOLVENTS FOR PETROLEUM

Source	Yield Gals. Oil per Ton	Carbon Tetrachloride: Per Cent Soluble	Carbon Tetrachloride: Per Cent Distl. Yield *	Carbon Bisulfide: Per Cent Soluble	Carbon Bisulfide: Per Cent Distl. Yield	Acetone: Per Cent Soluble	Acetone: Per Cent Distl. Yield	Benzol: Per Cent Soluble	Benzol: Per Cent Distl. Yield	Chloroform: Per Cent Soluble	Chloroform: Per Cent Distl. Yield
Kentucky	18.22	0.037	0.51	0.015	1.44	....	....	0.06	0.82	0.14	1.99
Utah (Soldiers Summit).	44.60	0.74	4.45	0.76	4.57	0.53	3.16	0.91	5.47	1.05	6.32
Colorado (DeBeque)....	37.75	2.04	15.42	1.85	13.97	1.33	10.04	2.23	16.84	2.41	18.22
Wyoming (Green River)	58.65	1.195	5.27	1.27	5.58	1.22	5.35	1.37	6.02	1.75	7.72
California (Ione)	52.00	7.555	33.46	5.83	29.68	10.98	55.80	...	....	10.16	51.73

* The second figure under each solvent "per cent distillation yield," represents the per cent of the distillation yield soluble in the solvent.

presence in the coals of different proportions of compounds containing unsaturated groupings. When lignite is treated with chlorine or bromine without external heating, the temperature increases to 90°-100° C. If the product of the resulting reactions is extracted with carbon disulfide, a halogen-containing resinous substance is obtained. Cross and Bevan have shown that coal is attacked by chlorine with the production of a chlorinated derivative similar to that previously obtained by them from lignified tissue. A shale oil obtained by distillation often contains 50 to 75 per cent of "unsaturates," so chlorination experiments [1017] were performed to determine if the unsaturated groupings are present in the organic matter of the shale, or if they are produced as decomposition products by the heat treatment; and to determine if it was possible to obtain little complicated chlorine products and to identify these products.

Shale from DeBeque, Colo., was suspended in carbon tetrachloride and chlorine gas passed through the solution for 36 hours. The solution was filtered through an alundum crucible, dried and weighed. The increase in weight resulting from this chlorine treatment was 0.59 per cent. The same sample of shale was then extracted with absolute alcohol in a Soxhlet extraction apparatus until the returning solvent was colorless. This solvent extracted 6.23 per cent from the chlorinated shale, calculated on the weight of the original shale. The same solvent extracts but 1.43 per cent from this shale before chlorination.

Shale from Ione, California, is soluble but 6.9 per cent in absolute alcohol. If treated with chlorine the percentage soluble was increased to 41.3 per cent. Efforts to identify this soluble material were unsuccessful. It is, however, apparent that the vigorous action of the chlorine gas on the powdered shale with the formation of an alcohol soluble organic material is ample evidence for the presence of unsaturated groupings in the organic matter of the shale.

Sulfuryl chloride reacts with higher olefins to yield dichlorides [1017]. Powdered shales treated with sulfuryl chloride at the boiling point of the latter (69° C) were reacted upon and the organic matter chlorinated. Shale so treated was increasingly soluble in absolute alcohol. Efforts to identify these chlorine derivatives were unsuccessful but indicated that they were of the same general character as those formed by treating the shale with chlorine gas, i.e., chlorine derivatives of unsaturated compounds present in the organic matter of the oil shale.

Microscopic Study of a few Typical Oil Shales

Under the microscope an American oil shale shows many laminations of dark brown to reddish colored material, separated by bands of almost colorless inorganic material. The bands of darker material usually are

parallel, but in places small faults cause the bands to cross or to unite. A Scottish oil shale is usually finely laminated, but the laminations may not become apparent until the shale has been burnt or retorted. A California shale consists of a very fine grained mosaic or argillaceous material, practically homogeneous.

Figure 14 is a photograph of a polished surface of an oil shale from Grand Valley, Colorado. This sample was obtained from an exposed ledge, striations of this shale being made more evident by the bleaching effect of weathering. Oil shales vary considerably in structure, and colors

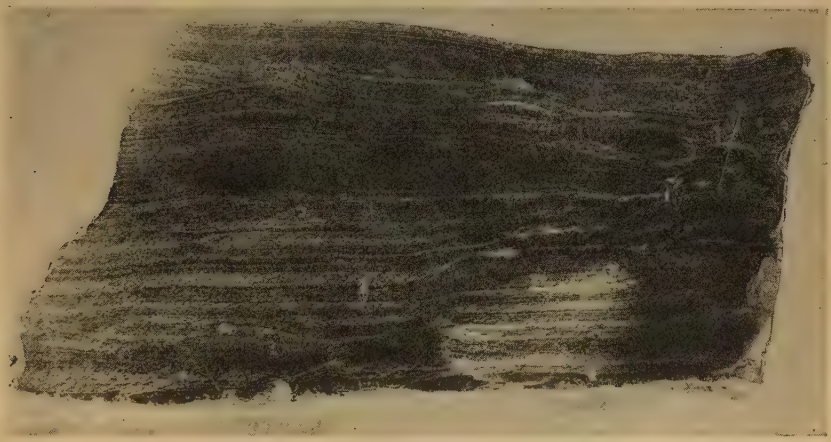

Fig. 14.—Grand Valley, Colorado, shale. The surface of this sample had been exposed to weathering, causing the color of the organic matter to change from almost black to a medium brown. This change of color was apparent for a depth of about ⅛ of an inch. The surface was polished with a buffing wheel and photographed. Parallel striations of organic material are apparent. Small local faults are evident.

range from the black Scottish shale to the light gray shale from Elko, Nevada.

The microscopic study of oil shales reveals the nature of the material from which the kerogen originated, and identifies the nature of the inorganic material with which the organic content is associated. A study of these factors aids in determining a definite, chemical procedure for the isolation and identification of the organic matter of the shale.

For microscopic examination, thin sections are made both perpendicular and parallel to the bedding planes. At a low magnification the sections have a yellowish appearance, with alternating bands of darker and lighter colors. (Figures 15, 16 and 17.) These alternating bands resemble very closely the alternations of lighter and darker colors shown in Figure 14.

Under the microscope all shales show a distinct coloration, which varies in different bands and shales of different formations. In thin sections this coloration is usually a reddish-yellow and ranges to a deep reddish-brown in thicker sections and in very rich shales. The coloration varies from lamina to lamina, probably as a result of differences in the chemical composition of the inorganic material. The coloration is very selective, as shown by the fact that grains of quartz and

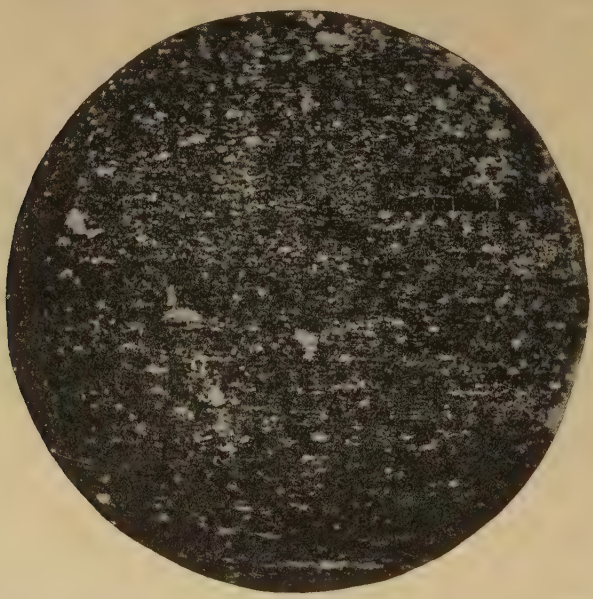

Fig. 15.—Elko, Nevada, shale (x 50). Section parallel with strata. The white, clear patches represent quartz grains. Pyrite particles are deep black and grouped in patches; organic matter, reddish brown with staining effect scattered through the shale in narrow streaks and lenticular patches. A few comparatively large streaks or bands of bituminous matter show transverse shrinking cracks. Clay substance is kaolitic and sericitic and forms mass of shale. Carbonates are absent.

calcite are not affected by it but appear clear and white, while the argillaceous matrix is deeply impregnated with the coloring matter. The clay matrix is exceedingly fine and occurs in laminae which are much thinner than the laminae of organic material of the section. Under higher magnification these bands resolve themselves into a series of more or less discontinuous thin laminae, of which the brown and yellow or dark ones are longer and more continuous than the gray or colorless ones. The mineral matter is very finely divided and a careful inspection shows that the dark laminae are usually not easily resolved into gran-

ules, while the light ones are made up chiefly of particles of crystals of mineral matter. The thin sections of the oil shales examined show the presence of vegetable debris as films or laminae which extend into the very fine clay material. In some shales a dark brown structureless material was present which probably originated in a collection of plant debris which has by decomposition passed into a jelly-like phase such as may be found in certain kinds of modern peat deposits. Associated with this

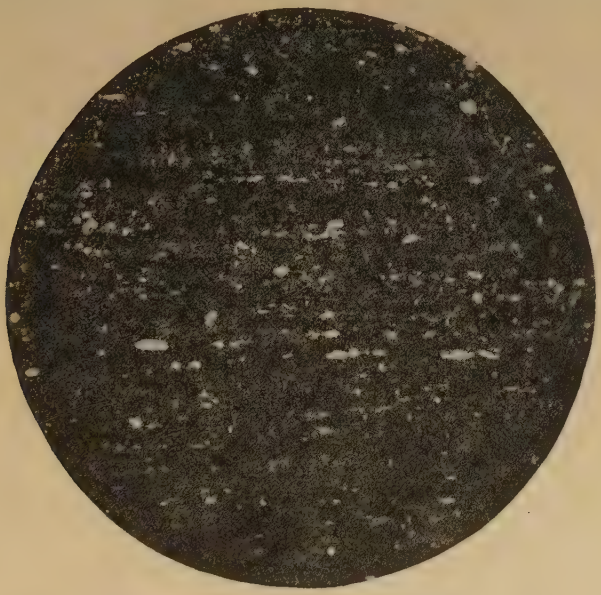

Fig. 16.—DeBeque, Colorado, shale (x 50). Parallel strata. Quartz grains, occasional (clear). Occasional pyrite grains in dense black patches or globules. At higher magnification the globules are composed of innumerable small cubes. Reddish-brown organic matter stains much of the shale mass. Occurs in dark streaks or bands, usually parallel. Occasional very dark streaks of organic matter associated with dark specks of the same material. Mixed body of the shale is composed of kaolitic matter, sericitic product and carbonate. Light gray portion is carbonate very finely divided and not stained by organic matter.

plant debris are numerous fragments of spores, usually in a very poor state of preservation.

Thiessen has reported [848] a microscopic study of the Devonian oil shales from Illinois, Indiana, Ohio and Kentucky and compares them with Scottish shales. The organic matter of the American oil shales examined consists very largely of spore-exines. Three kinds of relatively large exines are readily recognizable at a magnification of about two hundred diameters. The type of spore most conspicuous is Dawson's

Sporangitea Huronensis, but it is present only in small numbers. The spore exines are embedded in a mass which at a magnification of two hundred diameters appears structureless, but which at a higher magnification is shown to consist of numerous much smaller spore-exines very intimately intermixed with fine clay. Small spherules of pyrites are also distributed throughout the shale.

When the Devonian shale was treated with hydrofluoric acid, much of

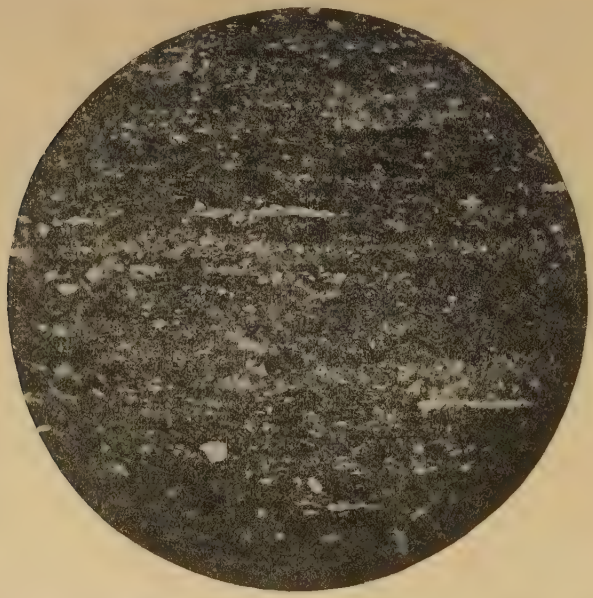

Fig. 17.—DeBeque, Colorado, shale (x 50). Parallel strata. Quartz grains, scattered (clear). Pyrite, scattered in black granules or in patches made up of a number of granules. Bituminous or organic matter occurs in two forms: (a) Reddish-brown staining substance, more or less giving a color to the whole clay matrix; (b) very dark to black streaks. Mixed body of the shale is made up chiefly of two constituents, both very abundant: (a) Clay substance, chiefly matrix; (b) carbonate occurring in numerous granules, scattered throughout the clay matrix.

the mineral matter was removed. The shale could then be cut by means of a microtome or be teased apart by means of needles under the microscope. The nature of the organic matter was easily observed and consists very largely of numerous disks closely matted together. Plant degradation matter other than that of spores is present in this shale in small amounts. The spore-exines found are those usually associated with the Carboniferous age. Oil shales of ages and formations other than those of the Devonian are composed largely of the same kind of con-

stituents but not necessarily of the same proportions. From this microscopic evidence Thiessen concluded that shales must have been deposited under aquatic to semi-aquatic conditions and derived from aquatic to semi-aquatic plants.

CHAPTER 5

FUNDAMENTAL FACTORS IN ANALYZING AND EVALUATING OIL SHALES

By Lewis C. Karrick

The Problem of Comprehensive Testing

A comparative study of the oil shales in the United States will have very little value unless, from the analyses or assays, definite conclusions can be reached as to the quantity and quality of the petroleum substitutes and by-products that may be produced from each shale. The operator of a prospective oil shale plant desires information that will enable him to predict the quantity and quality of oil and other substances that a commercial plant will produce. These data can only be secured through very comprehensive laboratory tests. This chapter brings out those principles of testing which must be recognized and applied in order that reliable data may be obtained and logical conclusions reached.

It is important that the analyst thoroughly understand oil shales—their properties and the mechanism of the oil producing reactions—in order that dependable results may be obtained regardless of the testing methods employed. Furthermore, he must recognize that oil shales are extremely variable in richness, and in physical and chemical properties, and also that the yield and quality of oil from any shale may be varied to an important degree by changing the manner of conducting the retorting. The difficulty of drawing definite conclusions as to the value of any oil shale from analytical data would be greatly reduced if results from successful commercial shale plants were available. But, since no commercial plants are yet in operation in this country, laboratory analyses cannot be correlated with commercial results.

An ideal analytical method would furnish data from which the results of commercial plant operation could be predicted. For oil shales and also for high volatile coals, which are to be subjected to low temperature distillation, the most practical and comprehensive scheme of analysis now available permits a wide range of variation, both in yield and in quality of the various distillation products, namely—oils, gases, ammonia products, and in the case of coals, coke residue. It is evident

that a commercial shale oil plant will operate at some point within this range of variation. If the same scheme of complete analysis is rigidly adhered to for each shale, adequate data for a comprehensive comparison of the different shales will be secured. Also, this information should make possible the selection of a commercial retort which embodies in its design the principles best suited for the production of a high yield of the most valuable products, as brought by the results of laboratory determinations on the individual shale.

The scheme of analyses herein described applies the fact that important changes can be produced in the yield and quality of crude oils obtained from any shale by variations in those retorting conditions which may be encountered in commercial plant operating practices: i.e., time and temperature of distillation. For complete description and discussion of apparatus and methods of testing oil shale see Karrick, "A Manual of Testing Methods for Oil Shale and Shale Oil": U. S. Bureau of Mines, Tech. Paper (published in 1925).

The curves of Figure 1 show how the yield and quality of crude oil is changed by varying the rate or temperature of retorting. These data were obtained from determinations on one particular shale, but similar experiments with many other shales show that curves of the same type may be secured for any shale. All the curves are plotted above the same horizontal axis, which represents the time required to effect uniform rate of oil production from the shale samples at the different rates of distillation used. Therefore, the points of intersection of any vertical line, say that representing two hours, with the different curves, show the properties and index value of the oil produced by a two-hour period of distillation conducted at a uniform rate. Also, curve Fig. 18 shows the temperature necessary to effect the distillations at the different rates.

The differences in quality of oils produced by one and eight hour rates of distillation show the necessity of retorting any particular shale in commercial practice at a definite rate and temperature of distillation if the products best suited for the available market are to be obtained. The data also should enable the plant operator to strike a balance between plant capacity—that is, rate or temperature of distillation,—and the two factors—yield and quality of products,—to the end that operations may be conducted in the most economic manner.

Need for Standard Apparatus and Testing Methods

The results obtained when oil shales are retorted are a function of the apparatus and methods used, as well as of the shale itself. Therefore, if reliable results are to be obtained, it is essential that a suitable

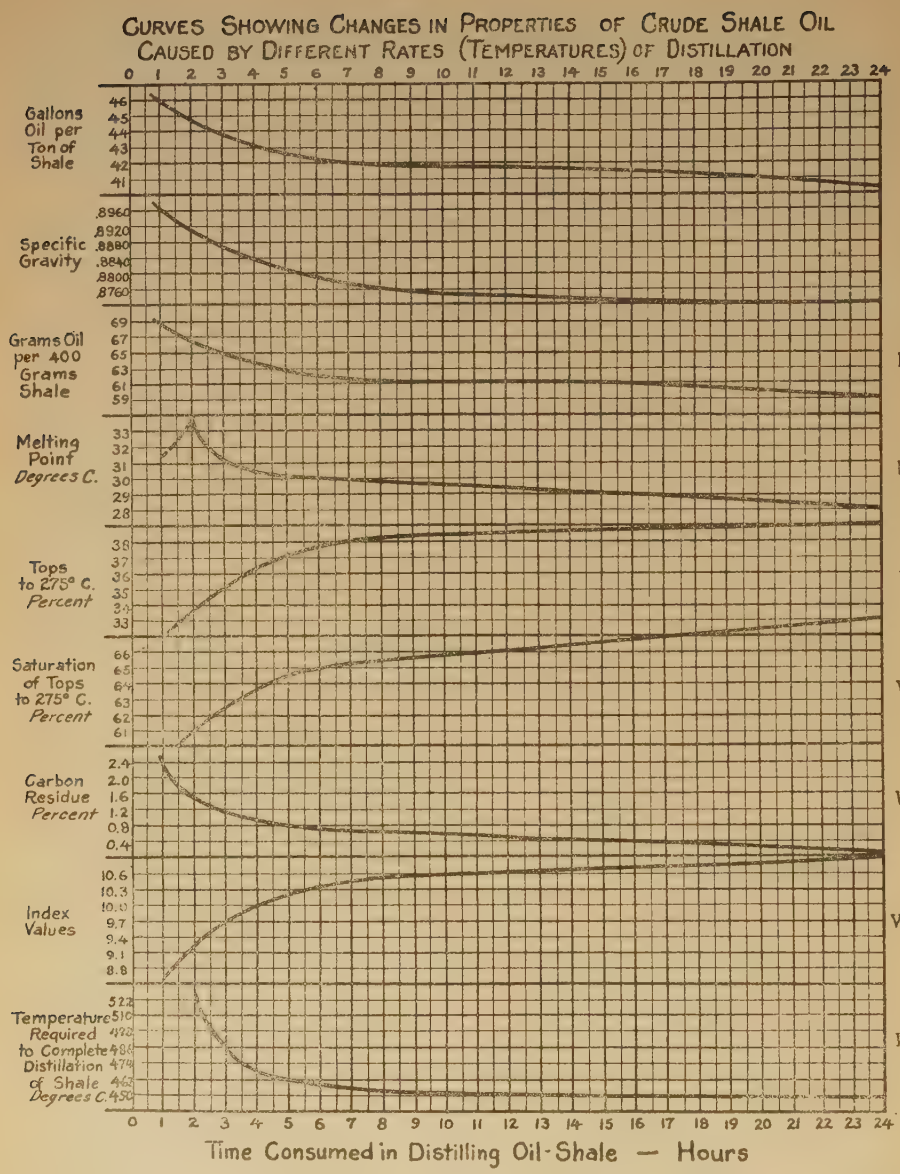

Fig. 18.—Distillation of oil shale at different rates.

standardized equipment and a definite standardized test procedure be used.

The apparatus and methods developed by the U. S. Bureau of Mines are the result of a number of years of intensive analytical study of oil shales from different parts of the world, and studies of methods of evaluating them. The results obtained with the Bureau's apparatus and methods compare exceptionally well with the results of Scottish and Australian commercial plant practice and are more dependable and more complete for purposes of research than the testing methods generally used in those countries. Since results with the Bureau's methods have been correlated with results of the only two present successful shale oil industries, the data obtained with these testing methods should be reasonably indicative of the results that may be obtained when any oil shale is distilled in the types of commercial retorts now being successfully used in those countries. The scope of data obtainable by these tests is sufficiently inclusive to cover the probable range of variation in yield and quality of distillation products that may be expected from any plant, and therefore, it is logical to conclude that these methods can be adopted as standard until such time as a successful domestic shale oil industry may indicate their limitations.

Many types of retorts for testing oil shale, and many oil and gas testing methods and apparatus are being used by different commercial oil shale analysts, so it is little wonder that results can rarely be checked either by the same or by different analysts. *It is obvious that oil shales can not be comprehensively compared as to yield and quality of products unless standardized equipment and methods are used and the conditions under which the distillations were performed are known and specified.*

Scheme of Tests to which Oil Shales and Shale Oils Should Be Subjected

Care in Sampling

To proceed diligently with a complete, well planned scheme of analysis is a waste of time and effort unless the samples being analyzed were selected and prepared with a degree of care commensurate with the value placed on the results of the assays. For the greatest accuracy in sampling undeveloped properties core drills should be used. This excellent though expensive sampling device is not usually available to most of those who desire analyses of their shales, but the more common methods of sampling, accepted as reliable for ore-bearing deposits, are satisfactory if properly applied. Shale samples are frequently richer than the average of the deposit they represent. The richer parts of the deposits are more

resistant to erosion and abrasion and form most of the projecting points on a freshly broken or weathered face of the shale. Many times, undoubtedly, these richer points form the bulk of the sample sent in for analysis.

Oil shales may be compared to fairly low grade ores, and it is therefore essential that assays be accurate and representative of the entire shale strata to be worked; otherwise the magnitude of the operations required for profitable manufacturing can not be anticipated in advance.

Factors which Affect Retorting Results

Since the results that may be obtained when an oil shale is retorted are variable (see Fig. 18), and can be changed at will by slightly altering the rate or temperature, each oil shale must be retorted at a sufficient number of rates to furnish information as to the range of variation in the yield and quality of products that may be produced. By using extremely high temperatures all gas and no oil may be produced or by applying very low temperatures in the destructive distillation very little gas and a maximum yield of oil may be obtained. These extreme conditions, obviously, will not be encountered nor even desired in commercial production of shale oil and, therefore, should not be used in testing oil shales. However, the abrupt changes in slope of the various curves in Figure 18 show that within a fairly well defined range of temperatures (rates of distillation) the changes in yield and quality of products are marked. This range is well within the practicable limits of commercial application, as is evidenced by practice in Scotland. The temperature in the distilling zone of the Scottish retort is such that 8 hours are required for complete distillation of the shale, and, therefore, crude oil of the same relative type as that shown in Figure 18 (8 hour rate) is obtained.

Possibly economic conditions in the United States will require that our oil shales be distilled at rapid rates. For rapid distillation finely ground shale may be retorted, or processes may be used in which heat is supplied internally to the distilling zone of the retort, but in larger quantities, and at higher temperatures, than is possible in the usual Scottish type of retort. The quality of a crude oil produced by rapid (high temperature) retorting is relatively poor, but this may be improved by subsequent coking distillation, which causes the same thermal decomposition that gives superior quality to the crude shale oils produced by slow rates of retorting.[1086] If it is more desirable to carry thermal decomposition of the oil to the economic limit in the retort, the relatively low temperatures of the Scottish type of retort will be necessary.

There are, perhaps, as many good arguments for the successful com-

mercial application of rapid distillation as for slow distillation, and it is likely that either method will offer commercial possibilities as attractive as medium rates of distillation. It is obvious, therefore, that if analytical data of oil shale testing do not include complete information as to the products which may be obtained under a practical range of retorting conditions, they are insufficient as a basis for comparing oil shales, or for providing figures on which to base plant design or operation. For the shale used to obtain data of the curves of Figure 18, the practicable retorting-time limits might logically be taken as one hour and eight hours.

Intensive study of the influence of time and temperature on the resulting products of distillation [1013] has definitely shown that the desired information concerning range of variation in yield and quality of products can be obtained by retorting the shales at five standard rates of distillation. The apparatus and conditions for conducting the distillations are briefly described in the following section.

Retort for Distilling Oil Shales

Figure 19 shows the details of the oil shale testing-retort used by the United States Bureau of Mines [821]. This retort was adopted after many comparisons with other types of apparatus, and is suitable for testing all types of oil shales. It is easy to operate, is subject to extremely low experimental errors (less than 1 per cent), and the parts are readily available at most laboratory supply houses.

When the retort is new the lid and base may not form a gas-tight contact. This defect is remedied by grinding the two parts together with fine carborundum and water, in much the same manner as in grinding gas-engine valves. (Cements or gaskets should not be used between the surfaces as they are not dependable, and after each run preparation of the surfaces for subsequent runs is difficult.) Slight grinding before each run insures that no oil vapors will escape during retorting and little time is required for this preliminary preparation.

The retort is completely filled with shale ground to pass an 8-mesh sieve and the lid clamped tightly in place. The contact between the lid and base should be tested for leakage by immersing the retort in water and forcing air into the delivery tube with the lungs. Any apparent leakage can be stopped by slightly shifting the position of the lid.

Standard Rates (Temperatures) of Distillation

In all distillations the heat should be continuously regulated so as to cause oil to collect in the receiver (10 of Fig. 2), at a uniform rate throughout the distillation. The time required for a distillation is the

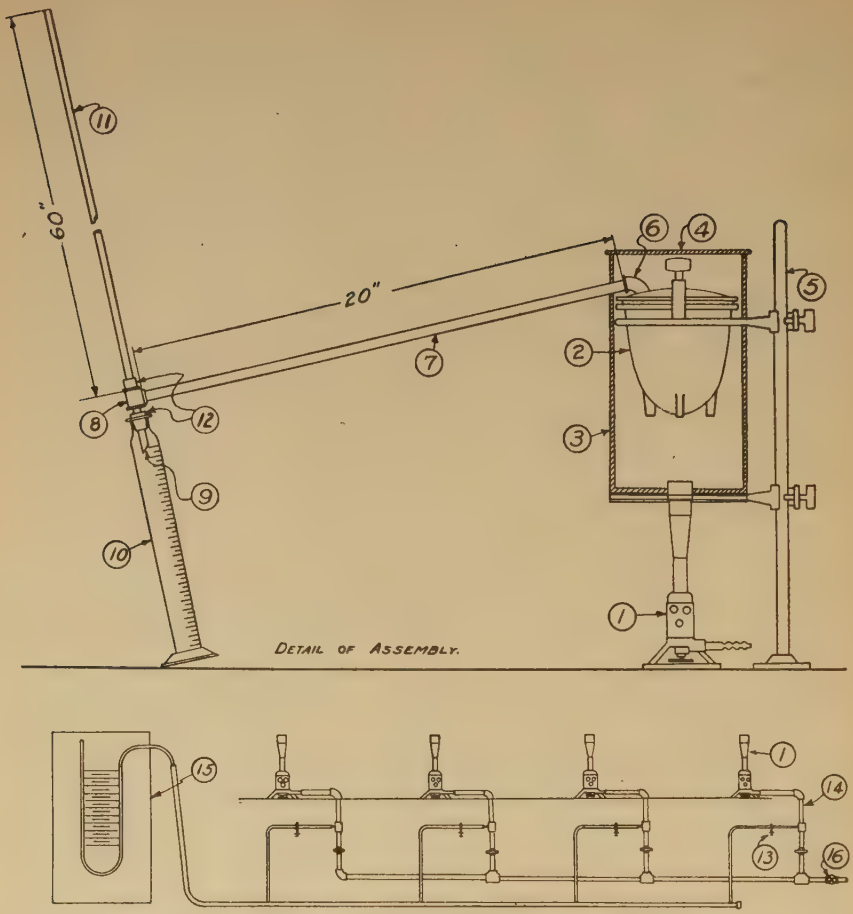

Fig. 19.—Oil-shale assay retort. Gas connections and manometer heat control device for a battery of four retorts.

No. 1 Gas burner.
2 C.I. mercury retort—pint size.
3 Asbestos-lined metal jacket.
4 Asbestos board cover.
5 Ring supports and ring stand.
6 ¼" street ell.
7 ¼" W.I. pipe.
8 ¼" tee.
No. 9 ¼" nipple cut at 45° on plain end.
10 100 cc. glass stoppered graduate.
11 ⅜" Pyrex glass tubing.
12 Best grade cork bushings.
13 Cutoff clamps.
14 Gas piping.
15 Manometer.
16 Main valve.

time interval consumed during oil production, and does not include the time (1 hour) necessary to bring the shale charge up to the temperature of oil formation. It would be very difficult to distill shales of unknown richness at a rate such that oil production would be completed in a defi-

nite time. But, it is relatively simple to retort any or all shales so that the oil is caused to form at any predetermined rate, that is, any number of cubic centimeters per minute. This procedure may be followed conveniently and therefore it has become standard practice to distill all shales at five definite rates of oil production, that is, one cubic centimeter of oil in 1, 2, 3, 4, and 5 minutes. Obviously, the distillation of a rich shale requires more time at each of these rates than a lean shale. From the results obtained by analyzing the oils produced at each different "rate of oil production," the yield and quality of oil which would be produced in any time—"rate of distillation"—can be determined either by interpolation or extrapolation. (See Figure 18.) A very convenient way is thus provided for comparing the many types of oil shales on the basis of yield and quality of oil produced under identical conditions or "rate of distillation."

Some confusion may result from lack of precision in the general usage of the expression "rate of distillation" as applied to retorting oil shales. It is correct to consider that shales have been distilled at the same rate when the distillations have been completed in equal intervals of time; this because the oil-yielding substances completely decompose thermally and pass through the oil-yielding range of temperature in the same interval of time, regardless of richness. Therefore, when all shales are distilled in, say, 1, 2, or 4 hours or any given period of time, they are correctly considered as having been distilled at equal rates. Frequently two shales are said to have been distilled at the same rate when oil was caused to form from them at equal rates. This is not the correct conception or expression of the idea "rate of distillation," since, if two shales, one twice as rich as the other, are made to form oil at the same rates, the richer will require twice as much time for distillation as the leaner, or in other words, the organic matter of the rich shale will decompose at half the rate of the decomposition of the organic matter of the lean shale. Curve IX, Fig. 18, and Table 1, show that the thermal decomposition takes place at different temperatures when the rates of distillation of shales are different, the organic matter being at a higher temperature when distillation rate is rapid.

TABLE I

Amount of Total Oil Yielded from Shale, Per Cent	Temp. of Shale, Retorted Rapidly, Deg. C.	Temp. of Shale, Retorted Slowly, Deg. C.	Difference in Temp. for Equal Progress of Distillation, Deg. C.
0 first oil vapors	365	360	5
25	425	400	25
50	440	405	35
75	460	420	40
100	525	460	65

Since shales of the same type, but not necessarily of the same richness, will be at approximately the same temperature for equal "rates of distillation," it can be concluded that the same thermal reactions tend to take place and similar products of distillation are formed. Therefore shales are compared under the nearest practicable approach to identical conditions when distillations are conducted at equal rates, that is, at the same temperature and in the same interval of time. It is true that a rich shale contains less mineral matter and there will be less catalyzed cracking. It is also true that vapors will evolve twice as rapidly from the richer than from the leaner shales and their high velocity of exit will permit less vapor-phase decomposition and also increase the amount of bitumen (primary decomposition product) [836, 837] carried out of the retort in suspension. This effect need not be taken into account in estimating the value of oil shales, other than to recognize that the oil produced at a given rate from a rich shale will partake somewhat of the character of oil produced at a slightly faster rate from a leaner shale.

Determination of Oil Yield

Insufficient care in measuring the accumulated oil may cause greater error in results than improper application of retorting principles. To measure the oil yield most accurately the receiver and contents (oil, water, and dust) should be weighed. Most of the oil may then be drawn off with a pipette and the remaining oil removed by successive washings and decantations with petroleum ether. The last trace of ether is removed by evaporation and the receiver and contents (water and dust) again weighed. The difference in weight is the exact weight of the oil produced. This weight (in grams) divided by the specific gravity of the crude oil equals the yield in cubic centimeters at the temperature at which the specific gravity was determined, preferably 60° F (15.56° C). The yield in gallons per ton is conveniently calculated by the expression:

$$\text{Yield of oil in gallons per ton of shale} = \frac{\text{c.c. oil} \times 239.66}{\text{grams of shale retorted.}}$$

Shale Oil Testing

Comparison of Shale Oils

The value of an oil shale as a source of crude oil is determined by both the quality and the quantity of oil produced from it. The Scottish shales give low oil yields as compared with the medium grade shales from the Green River formation of the United States. When these shales are compared on the basis of possible yield of finished products, the relative difference in value of the two shales is considerably less than would be

TABLE II

Location	Oil Yield, Gals. per Ton Crude and Scrubber Naphtha	Specific Gravity Crude and Scrubber Naphtha	Per Cent Crude Distilled to 275° C.	Per Cent Unsaturates Tops and Scrubber Naphtha	Carbon Residue in Air Residuum	Setting Point Crude Oil, deg. C.	Volume of Gas Cu. Ft. per Ton	Gross B. T. U. per Cu. Ft., Gas	Spent Shale, Per Cent
Soldiers Summit, Utah.....	49.68	0.894	37.2	36.9	1.71	28.5	1110	1100	74.96
Grand Valley, Colo.	36.71	0.899	38.5	42.8	1.72	25.0	943	957	80.58
DeBeque, Colo.	45.27	0.897	34.8	39.8	2.50	27.5	1221	965	76.95
Elko, Nevada	63.19	0.866	36.66	33.3	1.28	35.0	2070	1020	63.1
Sunnyside, Utah (Coal)	33.64	1.002	38.00	47.8	9.41	32.0	2980	972	68.92
Kentucky	16.03	0.934	40.9	44.2	9.79	< 0	931	1032	87.97
Brazil	118.69	0.870	40.5	33.6	1.51	19.0	2146	967	34.0
Australia	121.81	0.867	40.16	26.9	1.16	18.5	1121	1452	48.6
Scotland	17.66	0.872	37.6	23.8	1.68	33.0	731	731	86.7

concluded from a comparison based on yield of crude oil alone. Likewise, Australian shales are far richer than any shales of the United States, and the oils produced from the Australian shales by the same distillation methods are of superior quality. In this example, the comparison favors the foreign shale, but the advantage is greater than would be indicated by a consideration of richness alone. Several distinctly different types of oil shale occur in the United States, as is indicated by the kind of oils produced from them, and the properties of these oils affect greatly the probable uses to which they may be put. In Table II is given the analytical data of the oils produced from typical shales of the United States and from important deposits of foreign countries. The oils were produced by distilling all the shales under the same conditions. The wide variation in properties of the oils from the different shales indicates clearly the need for detailed testing of the shale oils by means of standardized apparatus and operating technique.

Fundamentals of Shale Oil Testing

The object of testing crude shale oils is to determine the properties of the crudes and the amount and character of the products obtained from them by fractional distillation. It is not to be expected, nor is it often necessary, that laboratory fractionations will separate the crude exactly into the same fractions as are made in the commercial oil refinery. The laboratory distillations have for their purpose the accurate and reproducible comparison of shale oils on the basis of fundamental properties.

The laboratory-distillation products of a crude shale oil referred to, for convenience, as gasoline, kerosene, etc., do not necessarily represent the yields of these trade commodities to be expected in commercial practice. The yields of finished products to be obtained from shale oil can not yet be determined by laboratory tests, since the possible commercial products and the methods of refining them are not definitely known. When finished products are actually made in commercial practice, laboratory and plant yields can be correlated, but until such time, it is not safe to predict yields from laboratory data or refining losses from petroleum refining practices. However, by the use of a well devised testing procedure crude oils from shales of unknown retorting and refining value may be compared with crude petroleums and with other shale oils produced and refined successfully in commercial practice. See Table III.

Tests Suited for Shale Oils

Shale oils may be analytically distilled by methods developed by the U. S. Bureau of Mines for the analytical distillation of petroleum (Bulle-

TABLE III

COMPARISON OF SHALE OILS MADE IN TESTING RETORT WITH SCOTTISH SHALE OIL PRODUCED COMMERCIALLY, AND AVERAGE QUALITY PETROLEUMS FROM THE PENNSYLVANIA AND MID-CONTINENT DISTRICTS

Source of oil	1 Scottish Shale	2 Scottish Shale	3 Shale from Soldiers Summit, Utah	4 Pennsylvania Crude	5 Typical Mid-Continent Crude
How produced	Scottish Commercial Retort	Testing Retort	Testing Retort	Oil Well	Oil Well
Retorting Time	6-8 Hrs.	2 Hrs.	5 Hrs.	.....	.....
Yield of oil		18.1	40.2		
Specific gravity of oil	0.867	0.864	0.882	0.812	0.835
Setting point of oil, Deg. C. ..	28	32	33	....	....
Distillation, first drop, Deg. C.†	49	44	40	26	30
Per cent distilled to 200 Deg. C.	12.22	16.63	18.81	31.93	28.0
Unsaturation, 200 Deg. C. fraction, per cent	28.0	34.1	40.2	3.6	4.0
Per cent distilled, 200-275 Deg. C.	23.22	20.47	20.10	20.83	15.0
Unsaturation, 200-275 Deg. C. fraction, per cent.....	34.0	34.1	40.2	3.6	4.0
Vacuum fraction to 200 Deg. C.:					
Per cent	9.32	2.10	2.64	3.33	4.0
Specific gravity	0.872	0.868	**	0.826	0.850
Viscosity	38	38	**	39	41
Setting point, Deg. C.	*	*	*	*	*
Vacuum fraction 200-225 Deg. C.:					
Per cent	5.27	4.38	7.80	7.75	6.0
Specific gravity	0.881	0.872	0.880	0.832	0.855
Viscosity	40	41	42	40	47
Setting point, Deg. C.	*	*	*	*	*
Vacuum fraction 225-250 Deg. C.:					
Per cent	7.16	5.88	9.20	6.02	7.0
Specific gravity	0.892	0.874	0.889	0.841	0.865
Viscosity	46	43	48	45	60
Setting point, Deg. C.	24.5	21.5	18	15.5	15
Vacuum fraction 250-275 Deg. C.:					
Per cent	6.13	7.30	14.90	5.37	4.0
Specific gravity	0.902	0.894	0.906	0.848	0.875
Viscosity	52	50	58	51	80
Setting point	29	29	31.5	22.5	20
Vacuum fraction 275-300 Deg. C.:					
Per cent	6.07	9.45	8.88	5.16	6.0
Specific gravity	0.911	0.898	0.928	0.859	0.890
Viscosity	60	60	72	67	130
Setting point, Deg. C.	34	37	40	30	30

* Not determined.
** Combined with next higher cut.
† Fixed-gas gasoline not included in crude used for these distillations.

tin. 207), modified slightly because of the different nature of shale oil. Three hundred cubic centimeter samples of the crudes are distilled at atmospheric pressure and fractions cut at every 45° F. (25° C.) vapor temperature-rise up to 527° F. (276° C.). The residuum is then distilled at 40 mm. absolute pressure, and similar cuts made in 45° F. (25° C.) steps up to 572° F. (300° C.). The specific and A. P. I. gravity of all fractions are determined. The fractions of the air distillation which distilled below 392° F. (200° C.) are combined to form the "crude gasoline and naphtha" cut, and the "unsaturation" of the mixture is determined. The fractions distilling between 392° F. (200° C.) and 527° F. (275° C.) are similarly combined to form the "kerosene" cut and the "unsaturation" percentage is determined. Viscosities (at 130° F.) of the vacuum fractions are determined with a pipette viscosimeter. Conradson carbon-residue values are obtained for the "air" and "vacuum" residuums. The dust and water percentages in the crude and melting points of the crude and the vacuum fractions are also determined.

Index Value of Shale Oils

Shale oils are generally considered to have their most important future value as sources of motor fuels. The "motor fuel" fraction, that is, the fraction boiling below 527° F. (275° C.), serves sufficiently well at present, as a basis for determining relative values of shale oils. Empirical indexes based solely on the amount and nature of the "motor fuel" fractions, have been suggested tentatively as a means of evaluating and comparing shale oils. The index value of a particular shale oil is the product of its percentage of "motor fuel" and the percentage of "saturation" of the motor fuel fraction. (See Curve VIII, Fig. 18.) The index value of an oil shale is the index value of the oil produced from it, multiplied by the oil yield of the shale expressed in gallons per ton.

Collection and Disposal of Fixed-Gas Gasoline

The amount of crude oil collected when an oil shale is distilled may be increased several per cent by the addition to it of the light hydrocarbons carried in the fixed distillation gases. These hydrocarbon vapors may be removed from the gases, preferably by "scrubbing" with "mineral seal oil" or activated carbon. If these light hydrocarbons are not added to the crude oil, the gasoline fraction will be so deficient in low boiling hydrocarbons that it will not meet present specification requirements for motor gasoline. These light hydrocarbons, known as "fixed-gas gasoline," should be added to the gasoline fraction before specific gravity and percentage of "unsaturation" are determined.

Production of Ammonia from Oil Shale

Oil shales can not be comparatively evaluated unless accurate data are available as to the possible yield of ammonia. Ammonium sulfate is the most valuable by-product in the Scottish shale oil industry. Hence its probable value as a source of revenue to a domestic shale oil industry should be considered carefully.

The nitrogen compounds in oil shale do not begin to yield an appreciable amount of ammonia until a temperature of approximately 750° C. is reached. Steam is necessary in the ammonia producing reactions, and the conversion of the nitrogen compounds increases with increase of temperature and concentration of steam. For determining actual yields of ammonia from oil shales the temperature of, and the amount of steam supplied to, the retort must be accurately controlled if agreement in duplicate determinations is to be expected. Commercial plants may not give the same yield as that of a precise laboratory method, and therefore it is more satisfactory to determine by analysis the amount of nitrogen in the shale, and calculate from this the amount of ammonia probably available. In the Scottish retort, 65 per cent of the nitrogen of the shale is converted into ammonia and this recovery may be expected from the domestic shales if sufficient steam is used in the retort and a temperature of approximately 815° C. (1500° F.) is reached in the reaction zone.

To calculate the probable amount of ammonium sulfate available per ton of shale, multiply percentage of nitrogen by 94.3 and the product by 0.65, i.e., probable yield ammonium sulfate per ton

= per cent nitrogen in shale $\times$ 94.3 $\times$ 0.65

or = per cent nitrogen in shale $\times$ 61.3

Gas Yield from Oil Shales

It is hardly probable that the fixed gases from destructive distillation of oil shales will become a source of revenue for commercial shale plants in general. However, the gases will fill a large portion of the fuel requirements of a plant, and since fuel is a large item of expense in treating shales, the yield and fuel value of the gas should be considered as important factors influencing the commercial feasibility of oil shale retorting.

Gas samples for analysis in the laboratory testing of shales, should be collected without removal of the fixed-gas gasoline. The gas scrubbing media, "mineral seal oil" and activated carbon have selective actions on the constituent gases and thus considerably alter the composition of the residual gas. Correction for the amount of fixed-gas gaso-

TABLE IV

ANALYSIS OF SHALE GASES

(Air free)

Type	Source	Vol. Cu Ft. per Ton	* Gross B. T. U.	H_2S	CO_2	Ill.	H_2	CO	CH_4	C_2H_6	N_2
Massive	Grand Valley, Colo.	943	957	1.6	14.9	7.7	35.4	5.6	17.7	15.5	1.6
Coking mahog.	DeBeque, Colo.	1423	1088	3.7	15.7	9.3	32.8	6.3	18.0	14.2	0.0
Curly massive	DeBeque, Colo.	1221	965	2.1	13.3	7.6	38.4	6.3	20.6	12.5	1.3
Brown	Elko, Nev.	1214	1051	14.9	11.7	7.1	30.1	3.7	16.5	13.1	2.9
Massive	Soldiers Summit, Utah	1110	1100	8.9	10.7	9.5	31.7	3.9	20.0	15.3	0.0
Bitum. coal	Sunnyside, Utah	2980	972	1.1	5.2	4.9	25.8	8.7	46.0	8.3	0.0
Brown lignite	California	756	825	0.3	28.4	5.8	25.0	8.5	21.1	10.0	0.0
Oil sand	Athabaska	206		4.0	14.9	11.0	23.0	4.5	22.2	21.4	1.8
Massive	Australia	1121	1452	1.0	3.6	13.0	7.0	4.9	33.5	27.0	0.0
Massive	Scotland	715	731	3.2	35.1	8.0	26.8	2.9	11.3	9.9	2.8

* At 0 Deg. and 760 mm. Actual calorific determination.

line present can be calculated and applied, if necessary, to the analysis and calorific value of the "wet" gas. The laboratory data can not be expected to furnish figures as to yield, composition, and fuel value of the gases which can be directly applicable to commercial plants. The commercial plant, if of the Scottish type, will yield a large amount of water gas in addition to the fixed gases from the destructive distillation of the shale. The type and efficiency of the gas-scrubbing equipment used in the commercial plant will influence the composition and heating value of the residual dry gases. The laboratory analysis, however, provides a means of comparing the gases produced from the many types of shales when they are distilled similarly, and under the most practical range of conditions.

Table IV is a list of analyses of typical oil-shale gases.

Summary

In closing, the writer wishes to stress the obvious fact that it is useless for analysts to attempt to draw conclusions from the analysis of a variable substance, such as oil shale, any form of which is subject to variable analytical results, when a variety of types of apparatus and analytical methods are in use. Oil shale, so far as the yield and properties of various distillation products from it are concerned, is an "unknown" with variable properties. If the results of different laboratories and analysts are to be brought into agreement, standard forms of apparatus and methods of operation must be adopted. The translation of laboratory data into estimates of expected results of a commercial plant will probably entail considerable risk until some data from successful commercial plants are available.

The foregoing discussion of the evaluation of oil shales omits much description and detailed directions for operating testing apparatus which are described elsewhere. Until the test of time has proved the inadequacy of the methods of testing herein outlined and has replaced them to advantage, it would seem that their adoption would greatly assist progress in the oil shale industry by making possible the assimilation and correct application of the results of the scientific studies that are being made on this important natural resource.

CHAPTER 6

THE REFINING OF SHALE OILS

By E. E. Lyder

Shale oil is the product obtained by the destructive distillation of oil shale kerogen. The composition and character of shale oil are dependent on the manner in which it is produced from the shale as well as on the characteristics of the shale and pyrobitumen from which the oil is made. Although the shales of this country and therefore the shale oils made from them are different from those of Scotland, certain fundamental practices used there will undoubtedly be applicable here. By adopting the desirable points of Scottish shale oil and American petroleum refining practice and solving the special problems presented by each shale (being careful to choose the desirable shales) the refining of shale oil offers no unsurmountable difficulties.

The first product of the decomposition of the pyrobitumen in oil shale is a semi-solid asphalt-like material (a bitumen) which breaks down to produce shale oil. The exact nature of this bitumen is not definitely known but it has been shown that it is composed mostly of substances soluble in concentrated sulfuric acid.[1017] When this semi-solid asphalt-like material is converted into crude oil by the process of distillation, the product formed is only partly soluble in sulfuric acid. The oil coming from a shale retort may contain as much as 50 to 80 per cent of "unsaturated" compounds, depending again on the method of distillation. Those processes which approach destructive distillation will produce an oil containing the maximum amount of "saturated" compounds, while those which approach the process of simply distilling over the bitumen give the more "unsaturated" oils. (See Fig. 18.)

When shale oils are refined, the crude oil comes to the refinery as a more or less unstable material and the refining process must be such that it will not only separate this crude oil into its various products and remove the objectionable impurities, as in petroleum refining, but it must also convert as much as possible of the crude oil into stable products. This is accomplished to a large degree by successive distillations. The first distillation of the crude will yield a larger portion of "saturated" compounds and if it be distilled again, more "saturated" products will

be produced, and so on until the oil contains the minimum amount of compounds soluble in strong sulfuric acid. The following example illustrates this point.

The "unsaturation" (amount soluble in an excess of 1.84 sp. gr. sulfuric acid) of a crude oil from a commercial shale oil plant was 75 per cent. This oil was distilled to dryness in a one-pint cast iron mercury retort and the "unsaturation" of the distillate had now been reduced to 57 per cent. This distillate was again distilled and the "unsaturation" of the resulting product was 50 per cent. A fourth distillation reduced the "unsaturation" to 49 per cent, or practically the same as the third distillation. This shows one way in which shale oil changes character as a result of distillation. A further example of this change is the following data which were taken from the records of a commercial plant (Catlin Shale Products Co., Elko, Nev.).

	Soluble in Concentrated Acid, Per Cent
Crude Oil (Directly from the retort)	77
Once-Run Oil (The crude distilled to dryness without steam)	65
Re-Run Oil (The once-run distilled to dryness without steam)	53
Slack Wax (The crude wax containing oil)	21
Cold Pressed Distillate (Oil with all wax removed)	21
Gasoline Fraction (Topped from the cold pressed distillate)	30
Gas Oil (Topped from cold pressed distillate after gasoline fraction had been removed)	46
Lubricating Stock (Untreated)	40

Throughout the whole operation of retorting and refining, the production of crude and refined products from shale and shale oil can be considered as nothing more or less than the production and cracking of a heavy bitumen to produce lighter oils. Although the process takes place at atmospheric pressure it is none the less a cracking process, and thus a considerable refining loss must be expected. The high percentage of unsaturated compounds in the various cuts results in high treating losses as well as excessive carbon deposits when the oils are distilled to dryness. In Scottish shale oil refining practice, the loss, including coke, and gas amounts to about 24 per cent of the crude oil.

So much has been written about the refining of shale oils in Scotland that it is unnecessary to go into detail here, but a brief summary will be given. The refining process carried out by the Scottish Oils, Limited, is characterized by the running of small batches of oil in relatively small stills and by the large number of cuts made. Steam is used in all distillations except at the end of the coking distillations.

The oil is first settled free from shale dust and ammonia water and

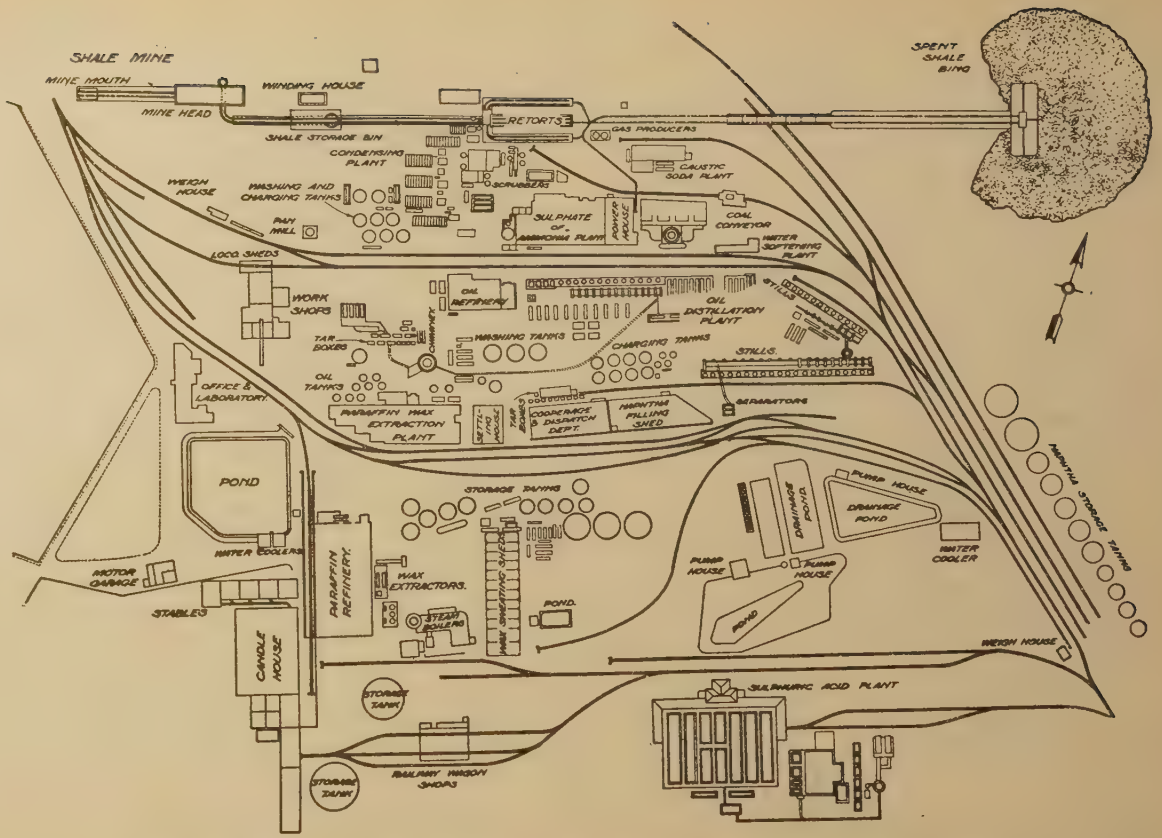

Fig. 20.—Plan of typical Scottish oil-shale retorting and shale-oil refining works.

then charged to the crude stills. These are largely of the continuous type and run off practically all of the oil as a distillate. The residue is then run to the coking stills for coking. In this coking distillation the product is cut into crude naphtha and a once-run or so-called "green oil," leaving the coke in the still. In distilling the crude oil and some of the fractions, as much as 1¼ cubic feet of gas per gallon of oil distilled is evolved. This gas is recovered and used as fuel.

The once-run or green oil is transferred to agitators, treated succes-

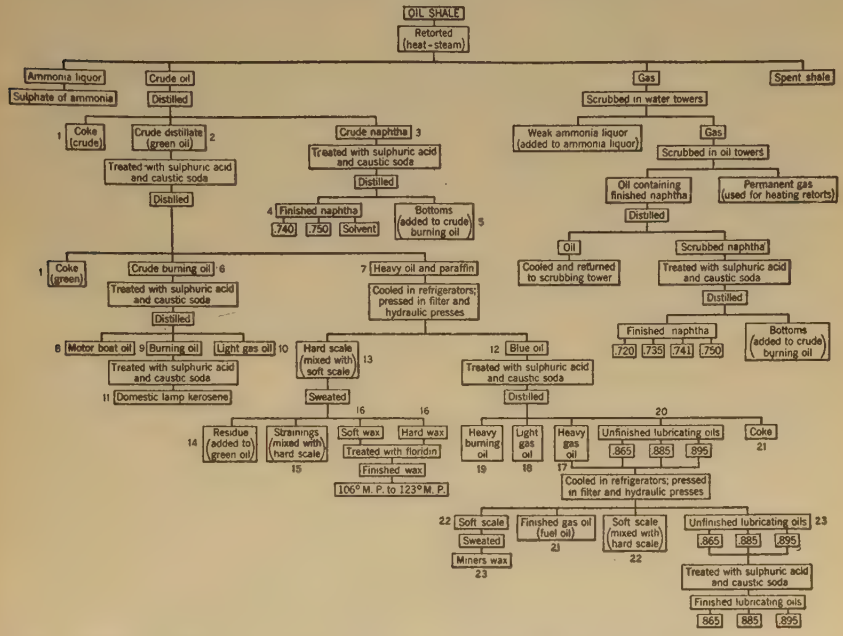

Fig. 21.—Chart showing the Scottish process of distillation of oil shale and refining shale oil.

sively with sulfuric acid and caustic soda, the tars removed, and then the oil is sent to the re-run stills. Here it is fractionated into naphtha, crude burning oil, and a heavy oil and paraffin, again leaving coke in the still. The crude burning oil from this fraction is mixed with similar fractions from other cuts, treated with acid and caustic, and redistilled to produce a motor boat oil, an oil which in America would be called an engine distillate. This fraction also yields a burning oil which is again treated with acid and caustic to produce lamp kerosene. The residuum from this distillation is a light gas oil.

The heavy oil containing the paraffin wax is cooled by a refrigerating

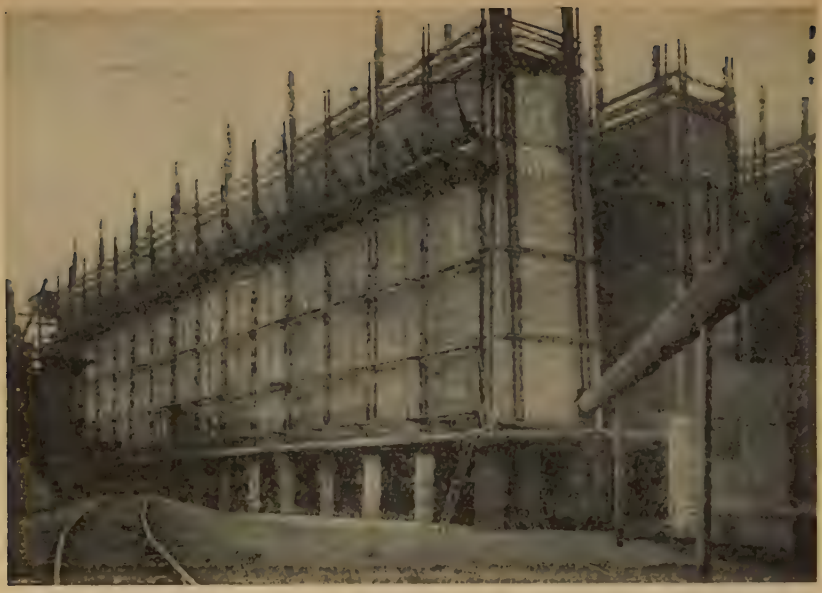

Fig. 22.—Pumpherston retorts for production of crude oil and ammonia.

Fig. 23.—Two benches of Henderson retorts at Broxburn, Scotland.

process and pressed to remove the wax. This is the first pressing and yields the slack wax from which the high melting "scale" is produced by sweating. The sweating process yields a foot's oil, which is mixed with the green oil, a soft scale, which is resweated, and hard crude wax scale. The hard scale is filtered through or treated with fuller's earth to yield the finished waxes. Every effort is made to produce the maximum quantity of the highest quality wax.

The oil from the wax pressing is called blue oil and is acid and caustic treated and redistilled, the products being a heavy burning oil, more light gas oil, unfinished lubricating stocks, and coke. The heavy gas oil is

Fig. 24—Scottish oil storage tanks—spent shale bing in the distance.

cooled down and pressed again, yielding a soft scale, which is sweated and marketed as miners' wax, and a fuel oil. Similarly, the unfinished lubricating oil gives another soft scale which is returned to the hard scale, and unfinished lubricating oil stock. The lubricating oil stocks are treated with acid and caustic and yield the various finished lubricating oils. The crude naphtha from the first distillation is treated with acid and caustic and redistilled to produce the various grades of naphthas.

In addition to the products removed from the crude shale oil proper, a volatile product, called scrubber naphtha, is recovered by washing the gases from the shale retort with a solvent oil, a method similar to the absorption process for the recovery of gasoline from natural gas. This scrubber naphtha is recovered from the solvent oil by distillation, treated

with acid and caustic and redistilled to yield light finished naphtha and a residue which is added to the crude burning oil.

The above very briefly outlines the various steps passed through in the production of finished products from Scottish crude shale oil. Some of the heavier fractions are distilled over caustic soda in order to remove undesirable constituents. The quantity of acid used (usually 66° Bé.) is about 3 per cent by volume of the crude oil treated. The caustic used throughout the refining process amounts to about 11 pounds per hundred gallons of crude oil treated. Acid sludge to the extent of 16 per cent of the oil treated is recovered and used as fuel and nearly 60 per cent of the acid used is recovered and reused for refining or making ammonium sulfate.

The products made and marketed either directly or indirectly are:

Gasolines and Naphthas	Sold in three or four grades as motor spirits, cleaners' naphtha, and solvent naphtha.
Burning Oils	Lamp oils, light-house oils, railway signal lamp oils, and engine distillates.
Intermediate Oils	Gas and fuel oils.
Lubricating Oils	Usually three or four grades. Sold either straight or blended.
Paraffin Wax	Sold in three or four grades and also made into candles at the plant.
Still Coke and Sludges	Used as fuel.
Gas	Used as fuel.

The various percentages of these products recovered are as follows:

Products	Percentages
Naphthas and Gasoline	9.9
Illuminating and Burning Oils	24.8
Gas and Fuel Oils	24.4
Lubricating Oils	6.6
Paraffin Wax	9.5
Still Coke	2.0
Loss and Gases (including tar)	22.8
	100.0

It is quite obvious that, inasmuch as products will greatly vary according to the methods of retorting used, refining methods can not be standardized until retorting practice is standardized. Crude shale oils will differ with the shales from which the oils are produced and refining processes must be varied for each particular oil just as petroleum refining processes differ for different petroleums.

Gasoline

The petroleum supply will decrease gradually. When the decline actually starts, petroleum substitutes, whether shale products or otherwise,

will be called upon to furnish only a part of the supply. Gasoline made by cracking the heavier fractions of petroleum is now used extensively to supplement the inadequate supply of straight-run gasoline. Cracked gasoline is usually not put on the market as a straight cracked product but is blended with casinghead or other low boiling point gasolines. Shale gasoline, whether produced directly from shale oil or by the cracking of the heavier fractions in pressure stills (Burton, Dubbs or other types) is a cracked product and must be handled in all respects as such.

Gasoline of proper volatility and free from gum forming compounds, excessive carbonizing properties and unpleasant odor can be produced from petroleum by treating with acid and caustic and steam distillation. With shale gasoline the same scheme will be followed except that more distillations and more treatments will be necessary. Since more unsaturated compounds are present in shale gasoline fractions, the loss on treatment with strong sulfuric acid is considerably greater than when gasolines are refined from petroleum.

Certain unsaturated compounds, such as some of the olefins, are not objectionable while others, the diolefins, are detrimental in the finished products. The refining process should be devised to remove only the detrimental constituents from the gasoline. An excess of strong sulfuric acid readily attacks certain members of the olefin series, removing them from the gasoline. Thus the acid is used up without completely destroying the coloring materials and strong smelling compounds present. For this reason the use of an excess of 66° Bé. acid results in high refining losses without thoroughly clarifying and deodorizing the gasoline. The gasoline may be effectively treated with various clays and color-removing compounds. Contact filtration with certain of these acid-activated clays or color-removing compounds together with treatment with relatively small amounts of sulfuric bids fair to be the ultimate method for refining a number of shale oil products. Especially effective are those activated materials which remove the various organic sulfur compounds which are present in shale gasoline to a greater or less extent, depending on the character of the shale from which the oil is made. Among the materials which may be used are the specially activated clays, absorbent carbons, activated fuller's earth, and silica gel. The hypochlorite wash used by some petroleum refineries for sulfur removal offers possibilities in connection with shale oil refining.

The use of catalysts in the production and refining of gasoline has not been marked with success. In fact, the aluminium chloride process is the only well known catalytic process used in the petroleum cracking industry. When it is properly applied, this process, at atmospheric pressure, converts heavy hydrocarbons into lighter ones and yields the much desired saturated products. This, added to the fact that aluminium

chloride is a deodorizer of shale oil, makes it an attractive reagent. The failure of the process to date has been caused by the high cost of aluminium chloride, or rather by the lack of efficient methods for its recovery for reuse.

Kerosene

Shale oil contains a considerable portion of those hydrocarbons boiling within the kerosene range. Because this fraction is highly unsaturated the production of a good burning oil from it will be expensive. Because of the odor given off on burning, sulfur is much more detrimental in kerosene than in gasoline, yet good kerosene can be and is made from shale oil in Scotland. However, kerosene will probably be one of the last completely refined shale oil products made in this country because of the above mentioned refining difficulties and because the fractions from which kerosene is generally made can be used to produce stationary engine or tractor fuel for which the requirements are not so rigid.

Gas and Fuel Oil

Shale oil usually contains a large gas and fuel-oil fraction which is available for gas making, fuel, or for cracking purposes. Its gravity ranges from 32 to 36° Bé. at 60° F.

Lubricating Oils

A lubricating oil fraction with a flash point of 375° F. or higher can be produced from shale oil. The viscosity of the finished oil is considerably lower than that of internal-combustion engine lubricating oils. Since only a small amount of work has been done on shale oil from different parts of the country, the average viscosity of American shale lubricating oils can not be stated, but lubricating oils with a Saybolt viscosity of 173 seconds at 100° F. have been produced commercially in this country. Viscosities of Scottish shale lubricating oils vary from 120 to 140 seconds and the average viscosity of the shale lubricating oils made in this country will apparently be about the same. The shale oil lubricant produced here, though of low viscosity, is apparently an excellent lubricant. Its viscosity decreases somewhat less with increased temperature than does that of petroleum lubricating oils. The shale oils stand up well under quite adverse conditions. The shale lubricating oils made by one company have been used successfully in practically all classes of automobiles and over such periods of time (two years or more) that there is no question of their ability to resist wear. They have

served in airplanes successfully, replacing the very heavy oils commonly used.

In the production of lubricating oils the same clarifying and purifying agents mentioned in connection with gasoline will undoubtedly find an equally important place. The finished shale lubricating oils contain a higher percentage of unsaturated compounds than do the ordinary paraffin base lubricating oils.

Wax

Some American shales yield a large percentage of a paraffin wax of good quality, while others yield little or none. In those oils which contain much wax, as for instance, the Elko, Nevada, oils, practically all of the oil produced from the first distillation must be carried through the pressing process. The pressing must also be done in two stages, which means that a greater part of the oil is pressed twice. From those shale oils which contain only a small percentage of wax, a wax distillate fraction can be made as in petroleum refining. Nothing unusual is involved in the production of paraffin waxes from shale oils. The melting points of the shale waxes thus far produced range from 105° to 130° American melting point, the average being 118° to 121°.

CHAPTER 7

THE NITROGEN CONSTITUENTS OF SHALE OIL

By Ralph H. McKee

Whatever the source of the organic matter in oil producing shales may be, it is always nitrogenous in character. The actual percentage of nitrogen in shales of this type is small, and varies in amount with the source of the shale. The best figures seem to indicate that the Scottish shales average about 0.60 per cent nitrogen, this figure being based upon a recovery of 60 per cent of the total nitrogen of the shale as ammonia, a recovery amounting to 35 pounds of ammonium sulfate per ton of shale. The remaining 40 per cent of the nitrogen is not recovered. Such figures for American shales as are now available indicate that the nitrogen content of most American shales is somewhat lower than that of the Scottish shales [419, 664].

When an oil shale is destructively distilled, the newly formed nitrogen compounds are distributed among the products of the distillation and appear in the form of ammonia and other basic compounds of nitrogen, mainly heterocyclic derivatives of the pyrrol (C_4H_5N) and pyridine (C_5H_5N) series. Part of the ammonia is dissolved in the water which condenses with the oil, part of it passes out of the condenser as vapor and is recovered in the scrubber. The shale oil contains varying amounts of nitrogen compounds in the form of basic tars of the pyridine and analogous series. The residual spent shale contains a considerable portion of the nitrogen, the chemical nature of which is not definitely known.

The amount and character of the nitrogen compounds formed during the destructive distillation depend upon a variety of factors, such as the type of retort used, the time of heating, the temperatures employed and the presence or absence of steam. Early in the history of the Scottish industry it was recognized that ammonium sulfate was to be one of the important products, so retort design and methods of retorting developed along lines tending toward maximum conversion of nitrogen to ammonia and at the same time the greatest possible amount of oil high in wax.

The effect of the time factor or rate of heating on the distribution of the nitrogen compounds was pointed out by Beilby [78]. The distilla-

tion of a typical Scottish shale yielded products in which the nitrogen was distributed as follows:

As ammonia	17.0	per cent total nitrogen
In the oil, as basic tars	20.4	" "
In the residual coke	62.6	" "
	100.0	per cent

When the same shale was retorted very slowly the distribution of the nitrogen compounds was changed as follows:

As ammonia	32.8	per cent of total nitrogen
In the oil, as basic tars	20.0	" "
In the residual coke	45.7	" "
Loss	1.5	" "
	100.0	per cent

Slow distillation not only tends to increase the amount of ammonium sulfate formed at the expense of the nitrogen compounds normally remaining in the coke, but it, also, is said to give a better grade of oil.

Just as slow distillation increases the yield of ammonia at the expense of the nitrogen in the residue, so does the use of high temperatures tend to increase the yield of ammonia at the expense of the basic tars normally found in the oil. These compounds are for the most part relatively unstable [777]. The higher boiling constituents of the bases decompose readily into ammonia on heating at atmospheric pressure, and although pyridine and its homologues are relatively stable compounds, the large portion of the basic tar is made up of compounds more easily affected by heat. On the other hand, even the use of a bright red heat fails to affect the nitrogen compounds remaining in the spent shale.

The use of steam in the retort during the distillation has been found to increase the yield of ammonia at the expense of the other nitrogen compounds and has long been the customary practice in Scotland. The yield and quality of the oil is likewise said to be improved by this treatment, although some doubt has been cast upon this effect by work of the Bureau of Mines [1085].

Although the recovery of ammonia has been such an important factor in the commercial success of the Scottish industry, the opinion has been expressed [459, 788] that ammonium sulfate will be of but minor importance in the development of an American shale oil industry. Such factors as the generally lower percentage yield, the higher cost of recovering and marketing the ammonia, together with the lower market value of the product, place the American and Scottish industries on a different economic basis. It has been suggested that it may be necessary in America, in view of its particular economic conditions, to sacrifice high

oil and ammonia yields per unit of shale to large daily plant production.

In Scottish shale practice, the recovery of ammonia does not differ materially from similar methods used in the coal tar industry. Oil vapors, permanent gases and steam pass from the retort through a common header into vertical air cooled condensers. The mixture of oil and water from the condensers is passed into a separator, where the ammonia water is separated from the oil. The permanent gases passing out of the condensers are forced through scrubbers to remove gaseous ammonia as well as light oil vapors which have failed to condense. The ammonia water from the scrubbers and condensers is distilled and the ammonia passed into sulfuric acid. The ammonium sulfate thus formed is crystallized and dried. As has previously been mentioned, the average recovery in Scotland is 35-36 pounds of ammonium sulfate per long ton of shale, a recovery of about 60 per cent of the total nitrogen of the shale.

The heterocyclic compounds of nitrogen which occur in shale oil have received but scanty consideration. Apparently they have been regarded as of no commercial importance, although solvent pyridine is a commercial product in the by-product coke oven industry, and is in demand in America for the manufacture and purification of anthracene and carbazole [580] and as a denaturant for grain alcohol. Crude solvent pyridine represents that fraction of bases boiling below 200° C. From American shales of Colorado and Utah the bases boiling from 200° up to temperatures as high as 390° are mostly methylated pyridines and closely related compounds. For this group there is at present no commercial source elsewhere and in consequence no industrial demand. What little work has been published on the identification and recovery of these compounds has been confined to shale oil derived from Scottish shale.

As early as 1854 Williams [22] isolated pyridine and several of its homologues in an investigation of the nature of the basic constituents of a shale oil naphtha distilled from Dorsetshire shale. Williams also noticed vapors of a pyrrolic nature, although he did not isolate pyrrol itself. The bases were obtained from a fairly low boiling naphtha and were probably all members of the pyridine series boiling between 115° and 180° C.

In 1879-80 Robinson [64, 66, 67] published a series of three articles describing some new bases of the isoquinoline series obtained from Scottish shale oil. The bases were fractionated until everything boiling below 270° had been removed, and the investigation was confined to that portion of the basic material boiling between 270° and 390° C. The author states that members of the quinoline series were absent, and that the compounds were all members of the isoquinoline series. This conclusion was based upon the fact that the bases failed to give

a blue color (cyanine dye reaction) when the amyl iodide addition product was treated with alcoholic caustic potash.

Twenty years later Garrett and Smythe [129, 135] worked on the basic tar extracted from Scottish shale naphtha, 200 gallons of which furnished 3 kilograms of dried and distilled base. From this mixture the investigators succeeded in isolating seven members of the pyridine series in the pure state. The compounds isolated and identified were pyridine (C_5H_5N), one of the picolines ($C_5H_4(CH_3)N$), four of the lutidines ($C_5H_3(CH_3)_2N$), and one of the collidines ($C_5H_2(CH_3)_3N$). The total yield of bases from the naphtha was about 0.3 per cent by volume. The boiling range was as follows:

Temperature °C.	Per Cent Distilled
Below 120	0.3
120-160	13.4
160-200	43.1
Above 200	43.2
	100.0

The investigators were unable to isolate in the pure state any individual compounds from that portion of the basic mixture boiling above 180° C. In order to compare the yield of bases from the "green naphtha" with the yield of similar compounds from the higher boiling "green oil," 20 gallons of each were treated and the bases recovered. The naphtha gave 226.3 grams of base, of which 63 per cent boiled below 200°, while the green oil gave only 120 grams of base, of which 40 per cent boiled below 200° C.

In 1905 Petrie [141] reported that the aqueous extract from crude oil obtained from the torbanite of New South Wales, while quite clear after filtering, developed a brown deposit of pyrrol-red on standing, and that the oil itself gave the deep ultramarine blue color characteristic of the test for pyrrol (C_4H_5N), when treated with isatin and sulfuric acid. A sample of water which had long been in contact with oil obtained from the DeBeque, Colorado, shales was recently found by the writer to give a similar deposit on standing, even after distillation had rendered the solution water-white. A pine splinter moistened with hydrochloric acid and held in the vapor stream during distillation, rapidly developed the purplish red color characteristic of vapors of a pyrrolic nature.

Few data are available regarding the amount of these bases, present in American shale oil, although several writers have referred to them. Woodruff and Day [215] reported the presence of pyridine compounds amounting to from 1.25 per cent to 6.13 per cent by weight in 15 samples of oil from shales of Utah. Winchester [398] gave the average nitrogen

content of the shales from the same source as 0.64 per cent, based on an analysis of 18 samples, and mentioned that part of this would probably be retained in the oil as pyridine bases. The nitrogen content of 3 samples of shale oil from the DeBeque, Colorado, shales was reported by Franks [777]. The results of Franks' work are given below, to show the distribution of the nitrogen compounds in the various fractions of the shale oil.

	Per Cent Nitrogen in Fraction		
Per Cent Distilled	Sample A	Sample B	Sample C
10	0.361	0.344	0.466
20	0.666	0.742	0.837
30	1.113	1.113	1.120
40	1.232	1.491	1.307
50	1.351	1.691	1.365
60	1.141	1.659	1.414
70	1.071	1.537	1.351
80	1.152	1.674	1.374
About 85	1.225	1.665	1.884
Crude Oil used	1.500	1.855	1.605

The percentage of nitrogen in the various fractions increases as the boiling points of the fractions become higher. This agrees with the earlier and similar observations of Beilby [80] and of Morrell and Egloff [384].

An investigation of the nature of the basic nitrogen compounds of American shale oil is at present being carried out in the Chemical Engineering Laboratories of Columbia University. Although this work is not yet complete, the following brief résumé of a few experiments will serve to give an idea of the amount of these compounds present in at least one type of American shale oil. The bases examined were derived from shale oil distilled from DeBeque, Colorado, shales. The results cannot be regarded as typical of American shales, for as has been pointed out, the amount and character of the nitrogen compounds may be varied within certain limits even in the distillation of a shale from a single source.

A liter of heavy naphtha (40° Bé. at 60° F.), cut at 300° C., was distilled from the crude shale oil, and treated with an excess of dilute sulfuric or hydrochloric acid for the removal of the basic constituents. The crude base recovered amounted to 7½ per cent by volume of the oil used. The specific gravity of the base was about 0.95 at 25° C. When freshly distilled the lowest boiling fractions were colorless, the intermediate light yellow, and the highest fractions deep red. All of the fractions darkened on exposure to the atmosphere. About 55 per cent of the crude base distilled below 200° C., this amount representing the crude "solvent pyridine." The boiling points of the fractions of the base taken direct from crude oil are shown in the following table.

Per Cent Distilled	Pressure	Temperature ° C.
1.1	Atmospheric	170-190°
3.6	"	190-200°
9.8	"	200-210°
16.4	"	210-220°
23.6	35 mm.	120-140°
33.2	"	140-160°
45.8	"	160-180°
60.0	"	180-200°
72.2	"	200-220°

Residue 27.8

Distillation was discontinued at a final flask temperature of 247° C. in order to avoid possible cracking.

Repeated fractionation of the above fractions gave a series of fairly constant boiling five-degree fractions which had a density range varying from 0.91 at 26° for the lower fraction to approximately 1.00 at 26° for the highest fraction examined, which boiled between 207° C. and 209° C. at 55 mm. pressure. The corresponding indexes of refraction at 26° for these fractions ranged from 1.5008 to 1.5603. These values correspond to the range of values characteristic of a pyridine series and are too low for those quinolines, isoquinolines, hydroquinolines and hydroisoquinolines which boil within the temperature range examined.

The nitrogen content of the fractions boiling between 192° C. (atm.) and 270° C. (atm.) was determined after further purification of each fraction and ranged from 10.28 per cent for the lower fraction to 7.42 per cent for the fraction boiling between 170° C.-173° C. (38 mm.) (a temperature range approximately one hundred degrees lower than the boiling range at atmospheric pressure). These values correspond very closely to a series of pyridine homologues ranging from $C_9H_{13}N$ to $C_{13}H_{21}N$.

The bases of the pyridine series were also present to a considerable extent in the water which had settled to the bottom of the oil containers after long standing. From two liters of this ammoniacal water 35 c.c. of base, boiling between 115° and 180° C., was recovered. The whole fraction was soluble in water, a characteristic of the lower members of the pyridine, but not the quinoline, series.

In order to obtain a series of fractions of greater purity and also to determine to what extent, if any, the primary and secondary amines are present in Colorado shale oil, a sample of the crude base was roughly fractionated at 40 mm. pressure, the cuts giving fractions 80° C.-140° C., 140° C.-175° C., and 175° C.-200° C. Higher boiling fractions were discarded. Each fraction was acidified with hydrochloric acid and steam distilled until the distillate was clear of oil material, reconverted to the free nitrogen base and the two lower fractions were steam distilled from

the alkaline mixture. The oily base layer was separated from the distillate and dried.

The higher boiling constituents of the basic mixture obtained from the Colorado shale oil are mostly alkylated pyridines and not quinolines (or isoquinolines) as are the bases from crude California petroleum investigated by Maberry,[646] which he concluded to be highly alkylated members of the quinoline (or isoquinoline) series, free from all but traces of secondary amines. A solution of the shale oil bases referred to in the preceding paragraph, upon treatment with an excess of sodium nitrite, gave almost no nitrogen gas, hence primary amines are present only in traces. However, it yielded considerable quantities of a sticky red oil, insoluble in water or dilute acids, and which was probably a mixture of nitrosamines formed by the action of the nitrous acid on the secondary amines present. After removing this oily material and neutralizing the acid solution of the base remaining, approximately one-half of the base originally used was recovered, undoubtedly all in the form of tertiary amines. Although it cannot be stated as a fact, through lack of present experimental evidence, it is probable that the higher boiling fractions of the bases are mixtures of alkylated pyridines, i.e., tertiary amines, and possibly hydrogenated members of this series, representing the secondary amines.

From the lower fractions of the purified tertiary amine there was obtained two picrate derivatives of constant melting point. One of these has been further identified by titrating a weighed amount of the picrate against N/10 sodium hydroxide, using phenolphthalein as an indicator. This compound is symmetrical collidine, or 2, 4, 6 trimethyl pyridine, whose picrate has a melting point of 155° C. Verification of the compound from which the other picrate is derived will be made, and although attempts to isolate the picrates of the higher fractions have thus far failed, it is hoped that further purification of larger amounts may lead to identification of at least some of the compounds present which boil below 275°.

It is to be noted that Robinson [64, 66, 67] succeeded after 25 fractionations in isolating the higher members of the isoquinoline series from fractions of Scottish shale oil boiling between 270° C. and 390° C. and which originally occurred in fractions boiling between 305° C. and 390° C. It is highly improbable that the quinolines, the isoquinolines, the hydroquinolines, or the hydroisoquinolines are present in more than very small amounts in the fractions of DeBeque, Colorado, shale oil which distill below 300° C. at atmospheric pressure. The maximum density of the highest fraction examined (190° C.-210° C., 24 mm.) (after two fractionations) was 1.0119 at 15° C.—considerably below the density of any isoquinoline or quinoline which boils within or below this

range. Apparently the chief series of nitrogen compounds of the shale oil of the Colorado field is that of the alkylated pyridine group. Those members of the series which boil below 170° C. (atmospheric) were not present in the sample examined, having been lost in the retorting process because of their solubility in water.

Whether these compounds can be made to yield products of commercial importance has been questionable. These bases must be removed in refining the oil, in order to make the oil marketable. Though the subsequent purification of the bases would require additional apparatus, the cost would probably be small.

The present commercial uses of these substances are limited largely by price. The pyridine group has a possible use as solvents, as insecticides, and for the denaturing of grain alcohol. Quinoline and its homologues, while not of any great importance at the present time, have been used in the preparation of a small group of dyes. Quinoline Yellow S, for example (the sulfonic acid of the phthaline formed by condensing quinaldine ($C_9H_6CH_3N$) and phthalic anhydride) is said to have a value in the silk and wool industries because of its peculiar greenish yellow hue and its fastness to light. Another group of dyes known as the cyanines and isocyanines are made by the action of caustic potash on the alkyl halides of mixtures of quinoline and lepidine ($C_9H_6(CH_3)N$). These dyes, together with Quinoline Red, are not fast to light, and are of use only as photosensitizing dyes in the manufacture of photographic plates.

Theobald has declared that pyridine is of great value as a substitute for nicotine in the control of apple aphids. But Frayer finds pyridine a weak insecticide and injurious to foliage when used in concentrations toxic to aphids. Richardson and Smith (U. S. Dept. Agr. Bull. 1160 of 1923), in a series of experiments on aphis rumicis, finds that pure pyridine (b. p. 115° C.) shows little toxicity to aphis rumicis, a 25 per cent solution being necessary to produce death. However, they find that a 15 per cent solution of alpha picoline is toxic, while a 2 per cent solution of quinoline or tetrahydroquinoline is toxic to aphis rumicis. According to Moore (J. Agr. Research, *9,* 371) the higher the boiling point (up to 250° C.) the greater will be the toxicity of the insecticide, in so far as there is a resulting adjustment of the volatility to gain greatest killing efficiency. For boiling point above the 250° volatility is usually too low to produce toxic effects at low concentrations.

Preliminary experiments under the author's direction were carried out with emulsions of crude nitrogen base from Colorado shale oil, emulsified with approximately 0.3 per cent solution of fish oil soap to ascertain the killing power on aphids of various species. It was found

that the toxicity increased somewhat as the boiling range increased with the maximum fraction distilling about 250° C.

The uses of these substances as outlined above are limited at present largely by their cost. Commercial pyridine, for example, cannot be used extensively as a solvent at the present market price of about $4.00 a gallon (1925), nor can dyes or other useful substances be developed from the methylated pyridines and quinoline bases when the latter are selling at a price between three and five dollars a pound. The recovery of these substances from shale oil, in which they have been shown to occur extensively, may easily lower the market price from several dollars to a few cents per pound. In this event it is probable that the commercial uses of the nitrogen bases would be extended in the same manner in which aniline and other nitrogen products were utilized when market prices dropped to such a value that they became commercially available.

It may be concluded that, in view of the competition which the shale oil industry must meet from well petroleum products, the development of possible by-products must be a topic of major importance, and that the nitrogen bases, which represent at least one of the possibilities, must not be overlooked in this connection.

CHAPTER 8

ECONOMIC CONSIDERATIONS OF THE SHALE OIL INDUSTRY

By W. A. Hamor

It is recognized by naphthologists that the future domestic supply of crude petroleum will not be equal to future home demands. This problem has been considered exhaustively from economic and technical viewpoints, and it is clear that it can be met only by the following procedure of attack:

1. By obtaining greater supplies of crude oil—
   (a) By increasing importations from foreign oil fields.
   (b) By actively participating in development of foreign oil fields.
   (c) *By establishing an American shale oil industry on a commercial basis as soon as is practicable.*
   (d) Through increased recovery from our oil fields, resulting from more efficient operating methods, and particularly from elimination of wastes in production.
2. By a better utilization of the crude petroleum now available. (See Chem. Met. Eng., *23*, 425 of 1920).

An analysis of this composite remedy makes it certain that the United States must in the near future lose its supremacy in the petroleum world and become more and more dependent upon the oil resources of other lands, except in so far as the situation may be saved by the successful industrial production of an artificial petroleum (crude shale oil) by the destructive distillation of American oil shales. (The probability that flush production from new domestic pools may from time to time reverse the general trend in no way modifies this conclusion.) The recognition of this fact explains the present general interest in the commercial possibilities of the kerogenous shales of the United States. Its economic importance is the reason for the constantly increasing amount of research attention that is being accorded to oil shale.

The production of natural petroleum in the United States must pass its peak at an early date—probably by 1927, according to the United States Geological Survey. When the domestic output begins to fall off, with increasing rapidity, due to the exhaustion of reserves, what relief

may come from shale oil production? This question, placed before specialists in fuel economics, does not bring an answer that is optimistic. While it is conceded that oil shale undoubtedly will be the basis for an industry of importance in perhaps the next decade, it cannot be gainsaid that it seems improbable that a commercial shale oil industry can originate soon enough or become sufficiently large to provide any considerable contribution before domestic natural petroleum production is already on the wane.

From the standpoint of the conservative petroleum technologist, to depend on oil shale, in view of present dearth of knowledge respecting its practical treatment, especially regarding the economical manufacture of refined products from it, is to trust to uncertainties, both as to costs and as to ultimate results. It is at best to superimpose on our present social and industrial fabric an enormous and complex new branch of manufacture, rivaling in part our coal mining, salvaging but a portion of our present petroleum industry and requiring many years for its technical development. If the quantity of coal mined in the United States during any recent year were all oil shale, of average crude oil yield, the amount of artificial petroleum producible therefrom would not equal the natural petroleum production for that year. Moreover, if shale oil yielding the principal and indispensable products cannot be produced and marketed as cheaply as natural petroleum from other countries, the public cannot be expected to build up and sustain a shale oil industry, unless it be under subsidy as a protective measure. It must be kept in mind, however, that the conservative petroleum technologist predicts that a commercial shale oil industry probably will be born in this country just as soon as it is provided with the necessary substantial foundation through systematic research and development. He is unimpressed by shale oil company publicity, and it is plain to him, through experience, that a real industry is impossible as long as the stock promoter and his "engineers" remain the prominent features of the situation. His interest is in an industry that has for its purpose the production of artificial petroleum from oil shale, and not the manufacture of chemical products. Accordingly, in this chapter no consideration is given to the production of crude shale oil for such specific purposes as flotation of ores, preparation of "sheep dips," manufacture of soap or to the proposed extraction of metals from spent oil shale [954].

Several American petroleum companies have acquired oil shale lands, for the evident purpose of retaining them as oil reserves. A number of oil shale tracts also have been taken up by persons connected with various petroleum companies, but they are not held in the names of those organizations. To illustrate, K. C. Schuyler and a group of other men, interlocked with the directorate of the Midwest Oil Company, have

acquired a large acreage near DeBeque and Grand Valley, Colo. From time to time large interests in the American petroleum industry have been reported as purchasing big tracts of oil shale land, but this information has not been confirmed.

Certain petroleum companies are accumulating reserves of knowledge regarding oil shale and shale oil, in order to have the data available for consideration at any time. The Gulf Refining Company, for example, has given the subject research attention.

It is of interest to mention here that a powerful British organization, the Anglo-Persian Oil Company, is operating the shale oil industry of Scotland, using the surplus capacities of the refineries for handling some of its crude petroleum from Eastern fields; and has, moreover, considered plans for shale oil works in New South Wales, Australia, and in New Brunswick, Canada. The crude-oil works and shale oil refinery erected in New South Wales by the Commonwealth Oil Corporation, of London, Eng.,[272, p. 842] were not operated by that organization after 1914 and the British-Australian Oil Company's mine at Temi was closed in 1915. Recently inquiries have been called for in Australia as to why British investors are allowed to hold an extensive oil shale lease without giving it developmental attention. It is reported that the Anglo-Persian Oil Company has purchased the plant of the British-Australian Oil Company at Murrurundi and expects to use the refinery for refining imported petroleum. It is not known definitely whether the Anglo-Persian Oil Company will go into the shale oil business in Australia. The old plant of the Commonwealth Oil Corporation was taken over by a company that is controlled by John Fell. It is said that this organization has erected modified Pumpherston retorts. The Joadja, New South Wales, oil shale mine, formerly worked by the Australian Kerosene Oil and Mineral Company, but closed down about twenty years ago, has been reopened by the Shale Petrol Oil Company, Ltd., which proposes to work coal and oil shale.

The discovery of oil shale in New South Wales dates back to 1802; its occurrence in Hartley Vale was noted in 1845; and real production commenced in 1868, when about 17,000 tons were mined. In 1914, 50,000 tons of oil shale were produced. Oil shale deposits have been located in several other Australian states, especially in South Australia, and also in Tasmania (at Latrobe). The Rialton-Latrobe shale works in Tasmania is said to be shipping crude oil to Melbourne to be refined and is reported to be installing a plant capable of distilling about 350 tons of oil shale per day. The retorting plant of Southern Cross Motor Fuels, Ltd., at Latrobe, has a capacity of 30 tons per 24-hour day.

In passing it is noteworthy that there is also substantial activity in connection with the commercial utilization of the oil shales of England

(Kimmeridge shale), Esthonia (Narva), France (Sâone-et-Loire, Allier, Puy-de-Dome, Basses Alpes, and Var), Germany (Messel, Merseburg, and Mansfeld), Graham Island (in the Queen Charlotte Islands), South Africa, and Spain (Teruel, Castellon, and Ciudad Real). Oil shales also occur in Argentina, Austria (Kufstein), Brazil, Bulgaria (western and central), Burma, Chile, China, French Cameroon, Italy (Lombardy, Udine, Salerno, and Vincenza), Japan, Morocco (Tangier), New Zealand, Norway (Auden, and Spitzbergen), Panama, Serbia, Siam, Sweden (central Sweden, and Oland), Switzerland, Turkey (Mersina), and Ussr (Simbirsk, and Perm).

Productive Values of Oil Shale Properties

The value of an oil shale or bituminous shale does not depend entirely upon the yield of crude oil by destructive distillation—that is, upon the content of kerogen, or oil-forming bituminous matter. Of first importance are the quality and refinability of the crude; hence the nature of the kerogenous substance and the method of distillation that is employed are factors that largely determine commercial value. Since the yield of ammonia from distillation is of importance, attention must be given to the percentage of nitrogen and to the character of the nitrogenous compounds in the oil shale.

The *productive value* of an oil shale property, therefore, is dependent upon the following considerations:

1. The demonstrated yields of crude oil and ammonium sulfate; that is, the crude oil and ammonia producible from each bed of oil shale that, on preliminary examination, gives promise of industrial availability. These findings may be expressed as the capacity per unit volume of workable veins on the property. Capacity determination can be based only upon representative samples of certain sources, so selected as to demonstrate the variation and continuity in the case of every industrially important bed on the property under investigation.

2. The quality or refining value of the crude oil. For the assurance of successful large-scale operation, a retorting process must be used that will give good yields of economically refinable crude oil and, wherever commercially possible, of ammonia [862, 900]. American oil shales are comparatively rich in characteristic kerogens, but in the Western States they are generally low in nitrogen content; while in the eastern Canadian provinces the oil shale is highly nitrogenous, although it yields an oil that is commercially inferior to the Scottish crude product.

3. The quantity of usable oil shale in sight. The supply of oil shale may be extensive and, in fact, practically inexhaustible; but prior to

actually beginning operations, a shale oil company should be able to claim, say, 50 years' supply of oil shale affording a minimum net profit of about $1.00 per ton retorted, assuming a throughput of, say, 1000 tons per day. The property should contain large (especially thick) and accessible seams of oil shale of uniformly high kerogen and nitrogen contents [425].

4. Favorableness of the location of the oil shale field with respect to shipment of products to the markets. The difficulties that are likely to be encountered in marketing oil shale products must be given attention. The petroleum industry of this country, established for many years, has developed an extensive and efficient system of marketing its products. Before shale oil products can become of commercial importance, it may be necessary to carry on a campaign of education, in order to convince the public that such products can be used with the same degree of satisfaction as those obtained from petroleum. The marketer of petroleum products has a distinct advantage through the largest oil refineries being located on the seaboard or near the marketing centers, whereas it seems that the shale oil refineries must be located largely in the Rocky Mountain region. It is thought by some specialists that this handicap will make the older and leaner shales of Indiana, Ohio, and Kentucky economically important.

It may be noted here that, if physical and economic conditions permit, the plant should be erected in the center of the field under development. The main factors to be considered in choosing a site for a shale oil plant are as follows: quality and quantity of oil shale, proximity of oil shale beds, mining conditions of oil shale deposit, water supply, facilities for disposing of spent shale, transportation facilities for the products, labor supply, labor housing, and market conditions. Of these, transportation must be given serious consideration; provision must be made for bringing in the machinery and equipment, some of which is very cumbersome, and for removing the crude shale oil or the refined products to market; a plentiful supply of water [1009] is absolutely necessary; and, if possible, the plant should be situated so that the spent shale can be removed easily by gravity. Oil shale camps are peculiarly favored, in that, before they are established, it can be ascertained with a degree of certainty that the life of the project is not limited. Unlike camps at metal mines, where the metal content of a given area is frequently an unknown quantity until after years of development, oil shale camps should, from the outset, be planned and built as permanent types of camps. Where this procedure is followed, camps will be established that will better serve the needs of the industry, and the cost of their general care and upkeep will be less.

Present Status of the Development of American Oil Shale Lands

The comparatively rapid exhaustion of our natural petroleum supplies, as well as the great magnitude of the oil shale deposits in Colorado, Utah and Nevada, has created a tremendous interest in the development of oil shale lands and processes. Over two hundred and fifty companies have been listed at Mellon Institute of Industrial Research during the last few years and since 1914 over one hundred and fifty patents have been issued, that describe alleged novel processes of getting crude oil from shale. Of the two hundred and fifty companies, some twenty have erected experimental plants, mostly quite small, and there is now no really commercial production of shale oil in this country, except possibly by the Catlin Shale Products Co. Inquiry has shown that a number of the companies are "wild-cat", stock-promotion ventures of the worst character. Other companies with honest intentions do not in many cases have good technical advice. The American people are warned that the difficulties of obtaining crude oil from shale at a profit are very great, and that it may be years before a successful shale oil plant assumes commercial importance in this country.

Speaking generally, the crude oil produced by the destructive distillation of oil shale resembles petroleum somewhat, but it is by no means identical with petroleum. For one thing, it is usually much more difficult to refine by the customary processes than petroleum. The only place in the world where there has ever been a truly successful shale oil industry of any size is in Scotland, and study of the Scottish experience demonstrates that technical men—chemical and engineering specialists—must have time to work out the many problems connected with an American shale oil industry. That research is not yet done, and until it is accomplished the immense American tonnage of oil shale must be regarded as an oil reserve for the future and not as a present supply. A number of technical observations have been announced by American experimenters as discoveries of importance which are not new, because the men who have made them do not possess the requisite fundamental knowledge. This situation has had a rôle in making something of a mystery out of certain operations that are well known to students of Scottish shale oil technology.

No sound contention can be made that any type of Scottish dual-purpose retort [459] should constitute the actual basis for the development of an American shale oil industry, for this retort is not the design that is required today to handle most economically all grades of oil shale; but it is essential that more careful consideration be given to Scottish experience in retorting practice as well as in general oil shale technology. This successful experience, and the misfortunes of those who attempted

to establish shale oil industries in Australia and New Zealand, have demonstrated that the retort and its operation must be adapted to the specific shale to be retorted, and always with due regard to local industrial, financial, commercial, and meteorological conditions. The unmodified Pumpherston dual-purpose retort was a failure when used in Australia because it was totally unsuited for dealing with the richly kerogenous, yet non-nitrogenous, shale of New South Wales; whereas the oil shales of Scotland are generally low in yield of oil and relatively high in yield of ammonia, when destructively distilled in the same type of retort. It is therefore not surprising that a large amount of money was lost in this attempt to obviate experimental work by adopting a retort that was very successful on a totally different variety of oil shale under entirely dissimilar economic conditions. As mentioned, American oil shales are comparatively rich in characteristic kerogens, but in the Western States they are generally low in nitrogen-content, while in New Brunswick, for instance, the oil shale is highly nitrogenous. In fact, almost every condition to be encountered on this continent differs materially from the conditions that have been responsible for the Scottish dual-purpose retort.

Shale oil is the logical substitute for petroleum, but it is inconceivable that it, considered in a large way, will ever be a competitor of petroleum. The oil shale industry will ultimately assume commercial importance, but many years and the services of the highest types of business, executive and technical ability, backed by large capital, will be required before it reaches this status.

CHAPTER 9

BASIC FACTORS OF THE SHALE OIL INDUSTRY

By Martin J. Gavin

The future of the potential American shale oil industry is dependent on the relative supply of, and demand for, petroleum and its products in the United States, especially in those regions close to the shale fields, and the possibility of securing from some source other than oil shales an adequate supply of substitutes for petroleum products.

An economic study of the status of American shale oil must therefore consider, first, the economic position of petroleum in the United States; second, the possible substitutes for petroleum and its products; and, third, the position of the oil shale resources of the United States as one of these possible substitute sources. It would be misleading to consider oil shale in any light other than as a possible source of mineral oils similar to those now derived from natural petroleum. The present economic importance of oil shales, and their future value, lies in their potentialities as sources of mineral oils. Not only must oil shale be capable of producing mineral oils, but these oils must be usable, and must be placed on the market at a price equal to, or lower than, equivalent petroleum products or other substitutes for them. Unless these conditions can be fulfilled there can be no shale oil industry in the United States. The purpose of the writer in presenting this discussion is to indicate that these conditions can and will be fulfilled, in all likelihood within a reasonable number of years.

Present Status of the Petroleum Industry

The writer's belief is that frequently a too short-sighted view has been taken in regard to the present and future of the American petroleum industry. The petroleum situation should be considered as extending over a long period of time, rather than as a problem of the day or a few years only. Temporarily, under certain economic conditions, petroleum production may exceed consumption; new domestic fields may for a time overbalance the general condition of excess of domestic demand over domestic supply; or a temporary surplus of imported oil

from foreign fields may produce the same effect; but when considered as a problem affecting several years instead of only a few, it is indeed difficult to escape the conclusion that the supply of oil available from the oil fields of the United States is far too inadequate to meet the demands put on it by domestic consumers of petroleum and petroleum products.

The science of petroleum geology has advanced rapidly during late years. A petroleum geologist is now pretty well able to tell where oil cannot be found, where it is not likely that oil will be found, and where it is probable oil can be obtained. Likewise, he is able to predict with considerable accuracy just how long a producing oil field can be depended upon to produce in paying quantities. The United States Geological Survey, co-operating with the leading geologists of the country, has made a survey of the petroleum reserves of the United States on the above basis, and has kept its results revised in accordance with the most recent developments in geological science and more complete knowledge of the present producing oil fields of the country. As a result of this survey, and making the estimate in a spirit of conservatism, the Geological Survey in 1919 [471] estimated that over 40 per cent of the nation's supply of petroleum, recoverable by present production methods, had been recovered and used in about 60 years. This left 60 per cent, or, as was estimated at that time, about 6,325,000,000 barrels of recoverable petroleum constituting our reserve. As the country is now producing petroleum at the rate of nearly 700,000,000 barrels per annum, this supply would be adequate for only nine years. Later estimates have placed the reserve at somewhat higher figures, and some have estimated the reserve as sufficient for 25 or more years, but whatever estimate be most nearly correct, or even if they all be 100 per cent low, our petroleum supply is evidently inadequate for future needs. The discovery of new fields necessarily hastens the rate of exhaustion, and long before a critical shortage exists the producing fields will have settled down into the long period of decline. Production can hardly be maintained at the present rate for many years. Petroleum will be produced for a great number of years, but as exhaustion gradually approaches its limit in spite of more intensive drilling to obtain greater supplies, it will not be possible to produce anywhere nearly enough petroleum for the demands of the nation.

Several possible expedients are to be considered in finding means to compensate for our diminishing reserve of petroleum. Of these may be mentioned: (1) conservation of existing supplies by more efficient production and utilization, (2) increased recovery from present producing oil sands, (3) importations, and (4) substitutes.

Conservation of Existing Supplies

This point requires little discussion. As petroleum supplies become more scarce, production methods will become more efficient, and already conservation measures have been enacted and are being enforced by various states. Petroleum refining is becoming more efficient, and refinery methods will be so improved that the greatest possible value will be obtained from each barrel of crude petroleum. The greatest possibilities for conservation seem to be in the field of utilization. Mention has been made of the comparatively inefficient use to which fuel oil is put when it is burned directly. The use of the Diesel and semi-Diesel engines will probably increase, and with it the more efficient utilization of our heavier fuels. Future automotive engines will probably use less and less volatile fuels and obtain a greater mechanical efficiency per unit of fuel consumed. That which is satisfactory fuel for the present day automotive engine would have been utterly useless in the gasoline motors of only a few years ago. The use of oil for enriching gas will probably decrease as the apparent tendency to lower the candlepower and calorific value of manufactured gas becomes more widely practiced. These and other means of obtaining a greater return per unit of petroleum will undoubtedly be of much assistance in warding off the time of critical shortage, but they can only delay it; they cannot postpone it indefinitely.

Increased Recovery from Present Producing Oil Sands

In the estimates of the United States Geological Survey, given above, the reserves of oil yet available were based on the estimated quantity capable of being produced by present production methods. The United States Bureau of Mines has, for some time, been studying means of recovering oil from sands now exhausted in so far as present production methods are concerned, but still containing much oil. It has been estimated that only from 10 to 20 per cent of the oil in most of the producing sands is recoverable by present practices. Mr. J. O. Lewis, former Chief Petroleum Technologist of the Bureau of Mines, is of the opinion that recovery from present producing, or old worked-out sands, can be increased from 50 to over 100 per cent by the application of proper recovery methods. If this opinion is correct, our reserve supply of petroleum may even be doubled, but this again only postpones the time of serious shortage, and oil recovered by the newer methods for increasing recovery can never be as cheap as oil produced by the common methods of production universally employed at the present day. While our supply of oil may be increased greatly by these new methods, the additional

production can be secured only at greater cost. Also it is not probable that this additional supply can be produced rapidly enough to take care of increasing consumption.

Importations

It has been shown that the United States, in 1920, was dependent on importations to the extent of over 20 per cent of its consumption. Most of this oil came from Mexico. Considerable reliance for future oil supplies has been placed on Mexico, but future petroleum production of Mexico is not at all certain. The present producing fields of Mexico are undoubtedly endangered by salt water encroachment. Many of the fields apparently have been ruined. That other fields may be discovered and developed in Mexico is certainly highly possible, but too much assurance must not be placed on this possibility, and if new fields are like the older ones, their lives will be relatively short.

The oil producing possibilities of great portions of the world are practically unknown. Certain districts, such as the region about the Caribbean Sea, the northern coast of South America, Persia, Mesopotamia, and other countries, are considered important as sources of petroleum, but just how much the United States will share in their development or oil production is a matter of speculation.

Foreign produced oil, however, under most circumstances, will probably be high priced oil. The United States cannot afford to depend on foreign sources for a major part of its supply of a commodity so important to its industrial life and national defense as petroleum. If adequate supplies of petroleum cannot be developed within the borders of the country, or in regions not likely to be cut off from the country in time of war, sooner or later it will be necessary to have some new source for an adequate supply of satisfactory substitutes for petroleum products.

Substitutes for Petroleum

There appear to be but three sources from which we may expect future supplies of energy now obtained from petroleum. These sources are: electricity, generated by water power or by the combustion of coal and the like; petroleum substitutes obtained from vegetable growth; and petroleum-like products derived by the destructive distillation of wood, coal, lignite, peat, oil shale, and similar materials.

The classification of electric power as a substitute for petroleum may seem ill-founded, but a little thought will indicate that the classification is not unreasonable. The hydroelectric possibilities of the country have been barely touched. Planned and projected water-power installations

are greater than anything yet attempted. Electricity has already been used to substitute for petroleum, and even for coal in some places. One of the largest railroad companies in the United States, using petroleum exclusively as fuel for its locomotives, is reported to be making extensive plans for the gradual electrification of its system. Another northern railroad has electrified over 600 miles of its main line system, and others are planning a change from coal or oil fuel to electricity. In regions of the country close to cheap water-power-developed electricity, coal and oil take positions of minor importance as sources of energy.

The increased cost of producing coal, and the still greater increased cost of transporting it to points of consumption, together with the knowledge that the long-time storage of coal, and the process of burning it directly under boilers, constitute a wasteful practice, have led to discussions of the possibility of the by-product coking of coal and generation of electricity at the mine mouth. The plan is that the coke would be gassified in producers and this gas, mixed with the distillation gases of retorting, would be used in internal combustion engines for the production of electricity close to the mine. The electrical energy so developed would be distributed over a large area of surrounding territory. Such discussions are not visionary. At the present time the Federal Government is investigating seriously the possibility of developing electricity on a large scale at mine mouths in the eastern part of the country. Such electric power, it has been suggested, might be tied into a trunk line system supplying the greater part of the Atlantic coast. To these trunk lines carrying electric energy developed in a most efficient manner from coal, it is also proposed to join the great hydroelectric plants, present and proposed, of the Eastern States. No discussion is required as to the effect of such power development on the use of coal and fuel oil in that part of the country, and if it is possible there, it may also be possible in other parts of the country.

The development of electrically propelled automotive vehicles has been held up because of the lack of a light weight storage battery with sufficient energy capacity for long continued operation, and because of the time required in replacing the energy of discharged batteries. Electrical development is still in its infancy and one would indeed be venturesome to predict the impossibility of great advances along these lines. In future power and energy developments, electricity is certain to assume a position of higher importance than it does to-day. The possibility of its substituting, in part, for the large quantities of fuel oil now being consumed in the country must not be overlooked.

The popular fancy has been caught by the possibilities of producing motor fuels and substitutes for other petroleum products from plant growth. Alcohol, produced from vegetable substances, and usually

blended with petroleum and coal distillation products, is now being placed on the market, and is being used with satisfaction as motor fuel. Alcohol can be used in internal combustion engines without blending, if the engines are designed for its use. Such use of alcohol will probably increase if the price of motor gasoline increases, or if the cost of producing alcohol decreases. The calorific value of alcohol is lower than that of petroleum products, but in its use in internal combustion motors this disadvantage is almost entirely offset by its high efficiency.

Alcohol can be produced from a great many vegetable growths and from vegetable waste products. Recent investigations indicate the probability that it can be produced from wood wastes, such as sawdust, though this yet evidently requires more convincing commercial demonstration.

The present and future position of motor fuels derived from vegetable sources has been aptly presented by Mr. J. O. Lewis, in an address before a convention of the Independent Oil Men's Association, in 1920 [626]. "Plant growths are renewing and are a permanent source of supply, but the carbonaceous materials of our rock formations are wasting assets that are not being replaced by nature. The production of alcohol, ether and vegetable lubricants from plants appeals to the popular imagination, but on considering the enormous quantities to meet even our present needs, the magnitude of the problem is seen to be appalling. This year's corn crop would make some seven billion gallons of alcohol, or about two billion gallons more than our gasoline needs, but obviously it would not be to the public interest to divert this amount of corn from its present uses, nor even the lands on which to grow such a crop in order to meet our motor fuel requirements. Food is beyond question our first necessity and as time goes on our needs for devoting the soil primarily to food production will become more and more vital." (This statement is but another way of expressing the results of the economic law that the population of a country tends to increase at a greater rate than its food supply.)

Like electricity, plant produced motor fuels will in future come to have a more important position in substituting for petroleum, but the growth of their production probably will be much slower than the rate of failure of petroleum supplies.

Practically all our present supply of lubricating oils is obtained from petroleum. Certain vegetable oils, notably castor oil, are excellent lubricants and thus a source of supply of lubricating oils is offered by plant life if or when the supply of petroleum lubricating oils fails, and if it cannot be supplied from other sources such as shale oil. The production of lubricating oils from vegetable material, however, is subject to much

the same limitations discussed above in connection with motor fuels obtainable from plant growths.

Lubricants can be made from much of the petroleum now being used as fuel and road oil. The demand for lubricants has not nearly reached the volume of the available supply of crudes from which they can be made. It is to be expected, therefore, that although our petroleum production may in future gradually decrease, petroleum lubricants will be available in quantity for many years. As petroleum becomes more costly with failing supplies, probably only those products in greatest demand will be made, and as fuel oil increases in price its use will be diminished, thus making available large quantities of oils suitable for the manufacture of lubricants.

A considerable amount of motor fuel is now being produced by the coal by-product industry of the United States, and blends of benzol and other light oils with petroleum distillates, or mixtures of alcohol and petroleum distillates, are on the market. The coal by-product industry is growing and gradually the wasteful practice of coking in beehive ovens, from which all the volatile products of the coal are wasted, is being replaced by by-product oven coking.

At present the problem of by-product coking is not so much the production of by-products as the production of a satisfactory coke, and the satisfactory marketing of that coke. Thus, in coking, the effort is not made to obtain the highest yield of, for example, motor fuels; but the highest yield of most satisfactory coke at lowest cost is the condition desired. Conditions for producing good coke are not necessarily favorable for obtaining high yields of motor fuel. Under present operating practices it has been estimated that if all the coal mined annually in the United States were coked in high-temperature by-product ovens, the material suitable for motor fuel thus made available would amount to only about 20 per cent of the annual domestic requirements for gasoline.

Other conditions of retorting coal will produce higher yields of oils satisfactory for motor fuels, but these conditions do not usually produce a marketable residue. Even so, it seems likely that coal by-products will be of much assistance in supplying future motor fuel requirements. If plans for the by-product retorting of coal at the mine mouth, as discussed above, are carried out the supply of material available for use in substituting for petroleum may be increased, and retorting methods may be developed that will yield a greater amount of suitable motor fuel per unit of coal than is now possible.

Coal distillation also yields other products which can be substituted for products of petroleum. In the eastern part of the country, large quantities of coal tar are used as fuel. The amount relative to the quantity of fuel oil used in the country is small, but with the growth of the

by-product coking industry this use of the heavier tars will undoubtedly increase.

The possibilities of obtaining petroleum-like products from low grade bituminous and sub-bituminous coals, lignite, peat and the like, should not be neglected. In different parts of the United States very large deposits of these materials are not now being utilized as fuel because of their high content of water and ash or other objectionable properties. The writer believes that in many places, where these deposits are favorably located and rich in oil yield, their development will be as feasible as the development of many oil shale deposits. The technical problems in the development of oils from these sources, however, will probably be considerably different from those involved in the production of oils from oil shales.

Petroleum Substitutes from Oil Shales

Before beginning a discussion of the position held by the oil shale reserves of the country as a new source of mineral oil supplies, the writer submits the opinion that neither the oil shales, the coals, the lignites, the peats, vegetable wastes, electric power, nor any of the suggested substitutes for petroleum will alone take the place of petroleum. Most or all of these substitutes will play parts of greater or less importance, and the development of one should not be wholly neglected for another. The development of substitutes cannot come rapidly enough, for both technical and economic reasons, to replace completely, for a great number of years, the expected waning domestic production of petroleum.

Of these various sources of substitutes for petroleum, the oil shale resources of the United States stand out prominently, and with perhaps greatest importance. For many years, oil shales have been worked commercially as sources of mineral oils in France, New South Wales, and Scotland, and their utilization in these countries makes it seem certain that the shales will be extensively worked in the United States as a source of such oils. The development of a shale oil industry in the United States will undoubtedly be of great commercial and industrial importance to the country, once economic conditions become favorable for it.

The amount of oil obtainable from the oil shale resources of the United States is so great as to make the amount of petroleum thus far produced and still awaiting production in the country seem almost insignificant. The United States Geological Survey has estimated that the oil shale deposits in the Utah portion of the Uintah Basin, alone, are capable of producing over 42,800,000,000 barrels of oil, and these constitute only a small portion of the nation's total oil shale reserves. Up to 1921, the United States has produced less than 6,000,000,000 barrels

of petroleum, and it has been estimated that that amount is over 40 per cent of the total quantity that can be produced with present production methods. Shale oil is capable of producing many, and perhaps all, the products now obtained from petroleum. Apparently it is but a question of time before these shale oil products will be produced and enter into the commercial markets of the country.

In the introduction to this chapter, the writer stated that the future of an oil shale industry in the United States depended on the relative supply of and demand for petroleum in the country, and the position of shale oil products with respect to other possible substitutes for petroleum. It has been shown that the nation's apparent supply of petroleum is insufficient to take care of the demand for mineral oil products for a great many years, and that limitations of a very practical nature hinder the rapid and extensive development of substitutes for petroleum other than shale oil.

There is as yet no shale oil industry in the United States. Since 1916 an increasing amount of work has been done on oil shale in this country, but shale oil has not yet been produced commercially. Many oil shale retorts of various designs have been proposed for use, several patented, and a few have been erected. These few are mostly so small that they must be considered as having been erected for experimental or demonstrative purposes only. Many investigators have been working in entire good faith, and much credit is due them for the pioneer work which someone must do before the industry can be placed on a firm commercial foundation. The potential industry, on the other hand, has been done much harm by the fake promoter and fake promotion company. The writer has records of over 150 companies that have been organized for the stated purpose of developing oil shale in one way or another, but which really were organized for the sole purpose of making a profit for the organizers or promoters through the sale of worthless stock or titles to oil shale lands not worth the paper on which they were written.

The writer does not intend to make this chapter an indictment of the oil shale stock promotion "game". Activities of this nature have been so widespread, however, that a word of caution is not out of place. Oil shale stock promoter's work on the speculative fever so commonly aroused by the mere mention of the word "oil", and they do not hesitate to make their project more attractive by the presentation of alluring prospectuses brilliantly illustrated and containing all sorts of impossible estimates regarding assured profits in oil shale operations. A careful study of such promotion literature cannot fail to indicate the falsity of such statements, and a study of the economic and industrial conditions under which a shale oil industry must operate in this country

still further shows the unsoundness of conclusions so often reached in the selling arguments and promotion literature of such organizations.

In the first place, the technique of shale oil production has not been established in this country. The trained engineer and technician quickly sees that many of the plants that have been erected ignore principles of good mechanical engineering and the application of the fundamental principles of technology governing the destructive distillation of solids. None of the plants have been operated long enough to indicate the cost of commercial production, or how long the plants will stand up under commercial conditions. Depreciation rates are not known with any degree of accuracy. There is a lack of trained engineers and technicians in present day shale oil work, and evidently a still greater lack of business ability. Sound constructive work is being done by several public and private investigators, but much more is needed, and even now much energy is being wasted because of duplication of effort among the worthwhile investigations.

Results of experimental work indicate clearly that different shales yield products of different natures, and that the same shale will yield different products under different retorting conditions. Further, it has been shown that some retorting conditions will yield, from a given shale, products that are practically worthless, while other retorting conditions will produce a reasonably good product. The production of oil from oil shale is not merely the problem of producing oil; it is the problem of producing a uniformly good oil, and producing it in the same uniform quality day in and day out for 365 days a year. In this light the problem is one for the technician, and most technicians admit that the problem is by no means completely solved.

Development of a shale oil industry in this country will not be hindered by a full appreciation of the problems before it; rather, its development can be hastened by full knowledge of these problems. The production and profitable marketing of oil shale products involves, first, mining; second, the technical and mechanical operation of destructive distillation and recovery of crude products; third, the chemical operation of oil refining and the production of other possible finished products; and fourth, the business operation of finding a market and placing these products on the market at a profit. The shale oil industry is therefore a mining industry, and because a large amount of raw material has to be handled to secure a small amount of finished product, it is an industry operating on low-grade raw materials. It is also a chemical manufacturing industry, as is the petroleum industry, and certainly it will be a business enterprise. Therefore the writer has always considered the shale oil industry a low-grade raw materials mining and manufacturing industry, making a small profit per unit of material treated, but, like

all industries of the same general type, depending on quantity throughput for a reasonable return on the investment. Such an industry cannot be successful without the services of technical, business and executive ability of the highest order.

Many economic problems are often overlooked or ignored by those proposing the development of shale oil. Some of these may be briefly mentioned.

As in the case of most industries, it will not be possible to secure absolute optimum results in all the stages of oil shale retorting and shale oil refining. Naturally, the operations will be so conducted that the greatest net profit will be made on the whole operation of placing finished products on the market. For each location, for every shale, and with each type of equipment used, the economic conditions conducive to the greatest profit should be determined. As an example, in Scotland to-day the most valuable product made from the oil is paraffin wax. It is easy to assume that conditions might change, and it might be advisable to leave as much wax as possible in the lubricating oils, or to crack the wax for the production of motor fuel. Market conditions must be studied, the permanence and stability of a demand for the different products should be determined, and the total net value of the products made and marketed be such that the shale and oil treating operations, as a whole, will yield the greatest possible profits.

By-products from oil shale and shale oil are frequent subjects of discussion. Among many, the impression has been created that the shale oil industry will succeed because of its by-products. All sorts of products have been mentioned in connection with the working of oil shales. The list runs from flavoring extracts to tooth powder. Possibly many of these reported products have been produced from oil shales, but their experimental production is entirely different from their commercial production and marketing. Many of the reported by-products are those for which at present there is but a limited demand. It must be appreciated that if such products as these could be produced on a large scale, from oil shale, their production might far exceed possible demand; and, notwithstanding their present high price, values might decrease to such an extent that their further production would be unprofitable, unless a new and greater demand could be created.

By-products are a rather unstable thing on which to build the success of a large industry, and the shale oil industry, if it is to succeed at all, will probably become a great industry. In the opinion of the writer, pioneers in the shale oil industry must expect to depend only on very conservative profits for a long time, and therefore should plan on making only those products for which there is a stable market and a strong demand. By-products, which are costly now because of their scarcity,

will command a much smaller price once they become plentiful, and estimated profits based on products subject to possible depreciation in market value through overproduction should be scrutinized with care. The products on which a shale oil industry can hope to base a stable foundation are likely to be those similar to the refined petroleum oils of commerce, and possibly some of the by-products of petroleum for which a stable market now exists. These are the products which the shale oil industry is expected to supply. If it fails to supply them it is not reasonable to expect that an industry of much importance can be developed from the oil shale resources of the United States.

Possible exceptions may be made to the above general conclusion. It is commonly stated that ammonium sulfate is a by-product of the Scottish shale oil industry. As a matter of fact, it is one of the most important main products. The success of the Scottish shale oil industry is dependent on the production of both oil and ammonia products. Were one or the other to fail, the industry would fail. The writer has been advised that ammonium sulfate is the greatest profit yielder of all the products of the Scottish industry. The production of nitrogen products, such as ammonium compounds, may be of much importance to the American shale oil industry, and other so-called by-products may become of equal or greater importance if a stable market for them can be created by the development of new uses, the increasing of present uses, or by considerable decreases in present prices by reducing production costs. The opinion is adhered to, nevertheless, that profits of the shale oil industry should be calculated on the basis of products for which a stable demand now exists, or for which a future stable demand can reasonably be anticipated.

The writer believes that much of the present enthusiastic discussion of the possible by-products of oil shales, and the large profits to be obtained from them, is extremely ill-timed, particularly as workers in the embryonic industry are not yet fully informed as to methods for making the principal product—crude oil—and refining that product into the marketable hydrocarbon oils of commerce. It is on these products that the shale oil industry must place its dependence for success.

Labor Supply

If an American shale oil industry were called on to replace the petroleum production of this country with shale oil, the oil shale production necessary each year would amount to about half the coal mined annually in the United States. In other words, the development of an oil shale industry in this country to the magnitude of the present petroleum industry would require for the mining of the raw material alone, a supply

of labor equal to nearly half the coal mining force of the country. In addition, labor would be required in the operations of retorting and refining.

This problem of labor supply is not serious now. In the Eastern oil shale regions it may never become particularly difficult of solution, but in the western mountain states, in which the great shale deposits are located, it will become a real problem, probably early in the commercial development of an oil shale industry.

No one expects the oil shale industry to spring over night into full being as an industry comparable to the present coal mining or petroleum industry. Its growth must necessarily be slow, but the ultimate probability of drawing, even gradually, hundreds of thousands of men from other industries, without seriously disturbing these industries, and organizing these men into an effective working force is so full of economic problems and practical difficulties as to deserve attention even now.

This large labor supply will for the most part be brought into a territory not now well inhabited and lacking in adequate transportation facilities. Housing and food must be provided, and these may not be simple problems in the mountain districts of the West.

Supplies

A large shale oil industry will create a considerable demand for certain necessary basic supplies. As examples may be mentioned iron, steel, and refractories used in retort construction, chemicals used in refining the oils and the manufacture of nitrogen compounds, timber and explosives for mining, fuel and the like. These supplies must be available, or be made available, and this suggests the possible necessity of developing industries subsidiary to the shale oil industry, located, in so far as possible, in the oil shale regions themselves.

Transportation

The problem of securing adequate transportation facilities will probably not be serious in the eastern oil shale fields, but in the principal deposits of the Rocky Mountain regions present transportation facilities could not adequately serve even a shale oil industry of moderate size. In this district most of the large oil shale deposits are many miles from railroads, and the present railroads are forced over excessive grades and roundabout paths by the mountains, with resultant high freight rates.

Naturally, at first, the shales close to existing railroads will be developed, but before the industry can expand to any great extent proper

and adequate transportation facilities must be available not only for incoming supplies but also because the chief markets of the shale plants will be at a considerable distance from the shale fields.

Marketing Shale Oil Products

The writer does not believe that shale oil products will ever be serious competitors of petroleum products. Shale oil probably will slowly replace petroleum as the petroleum supplies fail, and even under best conditions it will be many years before the shale oil industry begins to reach the size of the present petroleum industry. Therefore the marketing machinery and practices of the petroleum industry will probably handle shale oil products when they begin to come into the markets of the country in considerable quantity.

Advertising is likely to play no small part in developing markets for shale oil products. Shale products will have an odor considerably different from petroleum derivatives, and this odor may be more disagreeable than that of petroleum. Shale products may be more highly colored than similar products from petroleum; certainly they will be if excessively high refining losses are to be avoided. The importance of color of mineral oil products does not come within the scope of this paper, but highly colored products may be produced that will be equally as satisfactory as lighter colored or white products. Before such colored and disagreeable smelling products can be marketed, however, it may be necessary to conduct an educational campaign through advertising to convince the consumer that the products can be used as satisfactorily as old type petroleum products. The writer believes that many requirements as regards color and odor have been very much over-emphasized.

Plant Location

Several points with respect to plant location must be studied by those contemplating oil shale operations. Is a sufficient supply of oil shale available and may it be mined under favorable conditions? Can the shale be readily transported to the plant site? Is the topography of the plant site suitable for arranging a logical and economical flow sheet for materials in process, and is there room for future plant expansion? Can provision be made for ample dumping space for waste materials, including spent shale, which will amount to nearly the volume of the raw shale put through the retorts? Is there adequate water supply, and are plant wastes likely to be a nuisance to others located lower down on the drainage system? Can adequate provision be made to secure suitable living quarters and sanitation for the mine and plant

workers? These and other similar problems must be given careful consideration.

Water Supply

The problem of water supply is, in many places, likely to be the most serious of all these problems. This is not true of many places in the eastern states, but the situation may be serious in the West. In the western shale districts rainfall usually is sparse, and the water courses are few and widely scattered. Water may in many cases be obtained by drilling, and in other cases it is planned to divert water from the larger streams. However, irrigation is increasing in the West and the greater part of the water from many streams has been, or will be required for such projects. In each case the problem requires careful consideration, since it seems that from 150 to 250 gallons of water will be required for each ton of shale handled. (This includes the operations of retorting and refining.) In addition, water may be required in mining, and large quantities must be supplied for domestic use of plant and mine labor. In many places the strictest economies in the use of water must be practiced.

Importance of the Oil Shales

The greatest economic importance of the oil shales of the United States lies in the fact, as so many writers have stated, that they constitute a rear line of economic defense in assuring the United States a home supply of mineral oils. The shales are here, mineral oil products can be made from them, and they, together with the other possible substitutes for petroleum, furnish the comforting assurance that we may provide from domestic resources materials to fill the gap between our growing consumption and declining supplies of petroleum.

To the regions in which the oil shale deposits occur, they assume economic importance in other respects. Mention has been made of the labor necessary to develop an oil shale industry. In most places this labor supply will have to be imported and settled in regions now sparsely inhabited. These regions will be more densely populated by the development of a shale oil industry, and the earnings of the employees will be spent in districts close to the shale fields, thus adding to the prosperity of those districts. The development of the industry will require large amounts of capital, and thus a shale oil industry will increase the wealth and the value of the taxable properties of the states in which it is located. Auxiliary industries must be developed, further increasing the wealth, prosperity and population of the shale districts. The development of transportation facilities in the shale fields, together with the oil shale industry making available a reasonably cheap and adequate supply

of fuel, and possibly fertilizers, should assist in developing new mining and agricultural activities in the regions near the shale fields. In regions close to the shale fields of the West, there are agricultural districts of great potentialities, the greatest hindrance towards the development of which is lack of cheap fuel and present inadequacy of transportation facilities.

The petroleum industry is well established in this country; the shale oil industry is only beginning. At present the petroleum industry offers a more attractive form of investment than does the shale oil industry, if investment costs and cost of producing oil are considered in both cases. The petroleum industry, generally speaking, is a spectacular one; fortunes are sometimes rapidly acquired and, in many cases, as rapidly lost. There will be little of the spectacular in the shale oil industry. Profits will probably be conservative, but once the industry is firmly founded and properly managed, they are likely to be steady and assured.

The production of oil by drilling is not comparable to obtaining oil by the distillation of oil shale. Drilling operations frequently involve the element of chance, but rewards are often spectacular. Oil shale operations can be planned many years in advance, and there is little in which the element of chance can play a part. Shale deposits can be sampled with relative ease and the probable amount of oil obtainable from them calculated almost as readily. The rate of depletion of the deposit can be pre-determined, something not always possible with petroleum.

When petroleum is obtained by drilling, the nature of the product is what it happens to be. The nature of shale oil is largely governed by the conditions under which it was produced from the raw material. After the shale oil has been produced, its refining is likely to be more involved and complicated than the equivalent refining of petroleum.

The writer believes that in the next several years the supply of petroleum may so decrease and the demand for it so increase that petroleum substitutes will be necessary, particularly in regions remote from the seaboard. He has indicated the probability that shale oil can well be of major assistance in supplying these substitutes. No accurate prediction can be made as to when shale oil production will become commercial and profitable, as the relationship between supply of and demand for petroleum will determine the time, and the status of the petroleum industry during the next few years can hardly be predicted.

Undoubtedly, however, a shale oil industry will become firmly established in this country, and established on a sane basis. Limitations to its development have been mentioned, and other limitations are the actual amount of time required for experimental work, construction of plants, and the time required to secure capital. Many shale oil opera-

tors, and others, evidently choose to ignore these economic and technical difficulties. Nothing can be gained by glossing over the difficulties, or by underestimating the resources that will be required in their solution. Most rapid progress can be made in the shale oil industry when its problems are thoroughly understood, and squarely faced.

The development of the shale oil industry should be promoted legitimately and honestly. Facts and not unproven theories are needed. There is need for a greater co-operation by those attempting constructive development and among different investigators. Now is the time to make ready. Experimental and investigational work should be carried on with the fullest co-operation between government and private investigators, and between different private investigators, so that when shale oil is needed it can be produced with the slightest amount of delay and expense.

An idea prevails that the great oil companies of the country look with hostility on the possible development of oil shale, and that they are doing everything possible to hinder such development. There can be but little truth in such beliefs. The petroleum industry as a whole welcomes the development of shale oil. It realizes that shale oil will probably not be produced in competition with petroleum, but rather will gradually augment and replace our petroleum supplies. Probably the most constructive investigational work being done by private concerns in this country in connection with oil shales is being done by the large petroleum companies. Their attitude as to the future of oil shales is indicated by their acquisition of oil shale lands, particularly in the Rocky Mountain states. None are in better position to develop oil shales than are these same petroleum companies, and they appreciate that if they are to continue to have dependable supplies of oil they must be prepared to utilize oil shale.

In this connection a statement of an official of one of our large oil companies is worth repeating: "The oil shale industry, the coal refining industry, the power-alcohol industry, with their potentialities and their limitations, deserve our close consideration. While they may superficially appear as our competitors, they are fundamentally our allies. When the time is ripe, I believe these supplemental sources of supply can be developed by the petroleum industry more advantageously than by any other agency" [652].

Of the possible substitutes for petroleum, shale oil appears to be the most natural and logical. It would be a mistake to hail it as the sole successor, as other substitutes will play their part. The ultimate development in this country of a shale oil industry of great national importance seems assured, but its growth to such a position of impor-

tance will require many years, extremely large amounts of capital, and the best business and technical brains of the country. The oil shale industry is not a business for the man of small capital or those desiring quick returns on an investment.

CHAPTER 10

AMERICAN EXPERIMENTAL OIL SHALE DISTILLATION PLANTS

By W. A. Hamor

The following list includes all installations of which the writer has knowledge, and which are or were actual unit-plants, larger than laboratory size. This list has been made rather comprehensive, because of the historical value of the information, and it is not to be supposed that all of the plants mentioned are being actively developed towards large-scale operation. On account of prevailing conditions in the petroleum industry, some of these plants have been allowed to corrode away. Other ones in idleness possibly never had the assurance of sufficient financial support to make success possible. The processes are illustrative, however, of the trend of invention in this field, and their description should be of value for that reason alone. Undoubtedly, there are a number of other persons and companies that have small retorts or own "processes," but which are not mentioned because they have not attained the experimental or semi-commercial plant stage.

The rapidity with which embryonic processes of this kind may change status renders impossible accuracy in addresses given. The list is intended rather to serve as a guide to the student of the subject who wishes to get a general acquaintance with the processes that have for any reason whatever been deemed worthy of trial on a larger-than-laboratory scale.

A number of processes proposed primarily for the low-temperature distillation of peat, lignite, cannel and bituminous coals, and various other organic materials, are also claimed to be suitable for handling oil shale.[890, p. 394] In fact, several of these processes, e.g., the Bussey process (U. S. Patents Nos. 1,191,869 and 1,191,870), the Del Monte or Chiswick retort (U. S. Patent No. 1,196,470), and the Greene-Laucks process, developed by the Denver Coal By-products Company, of Denver, Colo.,[890, p. 466] actually have been applied to the destructive distillation of oil shale. Considerable technical progress has been made through scientific research in the field of low-temperature coal carbonization, and a number of the reports of this experimental work should be of suggestive aid in the scientific study of the pyrolysis of kerogen.

Some of the organizations listed probably will maintain that their plants are no longer experimental, but this term is used because of the present status of the technology of oil shale in the United States. No attempt is made to distinguish between unit-plants erected for techno-

Fig. 25.—Index Shale Oil Company plant near DeBeque, Colorado.

chemical research purposes and unit-plants put up for stock sales or licensing demonstrations. It must be borne in mind that the production of several hundred barrels of crude oil does not mean that a plant is a commercial success.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Anderson Shale Oil Company, 160 South Broadway, Denver, Colo.	Denver, Colo.	Anderson electric.	The Anderson electric retort consists of a steel hearth, 16 ft. long, 2 ft. wide, and 2½ ft. high, which is set horizontally and covered by an iron cap in which are baffle plates to separate the vapor chamber into five compartments, from each of which the vapors are led off through pipes to separate condensers. The hearth is heated from below in five segments by electric resister elements, so that the temperature of each segment can be regulated separately (365° F. in the first zone; 1350° F. in the last). Electricity for heating the retort is generated by an internal combustion engine in which the fixed gases evolved in the retort are used as fuel. Shale which has been crushed to pass a 20-mesh screen is fed continuously into the retort through a hopper at one end and moved along the hearth by mechanically operated rakes.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Bronder, L. A., Brooklyn, N. Y.	Brooklyn, N. Y.	G. A. Bronder (U. S. Patent No. 1,361,005).	In a hopper, on the top of the retort, coarsely broken oil-shale is preheated with the waste gases of combustion, a fan forcing them through the shale. After preheating, the oil shale is dropped into the main body of the retort, where it is heated to the temperature required for destructive distillation. The retort, which holds 1000 lbs. of oil shale, consists of a cylindrical vertical vessel with a heating box, filled with tubes of flues attached to it. There is an open circulating space at the bottom and another, interrupted by a wall, on the top. The entire charge of oil shale rests on a grate, and an exhausting fan sucks the air and vapors from the top of the shale, drives them along the outside of the flues downward, where they become heated, and through the shale upward.
Catlin Shale Products Company, Elko, Nev.	Three miles south of Elko, Nev. The refining plant is still in the constructional stage.	R. M. Catlin.	It is reported that the Catlin retort is designed to produce crude oil containing the maximum amount of paraffin from Elko oil shale. In one design, eight vertical retorts, 54 in. in diameter and 16 ft. in height, were arranged around a common center and heated by gas manufactured from spent or raw shale in a producer. It is claimed that the retort tailings contain sufficient carbon and hydrocarbon material to provide all the gas required during destructive distillation of the oil shale. For a descriptive account of the Catlin plant, see Shale Rev., *2* (1920), Nos. 8, 6, 25 and 31. This company is without doubt the most advanced in its technology in the United States, and not only built and discarded several retorts prior to the one described above, but is reported to have constructed a still more satisfactory retort, capable of a daily through-put of 100 tons of shale, detailed description of which is not available.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Continental Oil Shale Mining and Refining Company, 421 Cooper Building, Denver, Colo. (Organization of E. L. Krushnic).	Near Rifle and Rio Blancho P. O., Rio Blancho Co., Colo.	Colorado continuous, designed by Hartley and Dormann, 722 Colorado Bldg., Denver, Colo.	The Colorado continuous retort (capacity, 25 to 40 tons per 24 hours) consists of a vertical cast-iron chamber, 2 ft. in diameter and 22 ft. high, set in a brick furnace. The oil shale, crushed to ½-in. size, is fed from a hopper into the retort at the top and is lowered by a helical conveyor, which regulates the speed with which it passes through the distillation zone (temperature, 1000° F.). The vapors are withdrawn from the retort through a number of pipes at different elevations and carried through large air- and water-cooled condensers. Oil and the uncondensible gases are burned to supply heat for the retorting. The spent shale is removed by a mechanical device, through a water-seal at the bottom of the retort.
Day, David T., 715 19th St., N. W., Washington, D. C.	Schuman Cut, near Santa Maria, Cal.	David T. Day (U. S. Patent No. 1,244,840; see also No. 1, 280,178).	The original plant at Schuman Cut was operated as follows: The oil shale, crushed to egg-size, went over a belt conveyor with automatic feed to a hopper which supplied a screw-conveyor, 20 ft. in length, enclosed in a cast-iron tube, 16 in. in diameter. From this tube it dropped into a second, and then a third, each of the three tubes being heated in a furnace by waste gases from the retorting, which were burned in a Dutch oven along the lowest of these horizontal retorts. A rather unsatisfactory valve let out the spent oil shale without wasting much of the gas or vapors. This plant was operated for about one month in 1924 after Day had made some alterations in it, but is now closed. Another retort on the same property, a modified gas producer that held about 10 tons, was run once and shut down because of clinker troubles. A third retort, which will be continuous and of 50 tons capacity, is now in course of erection; it is said to resemble the Catlin type.

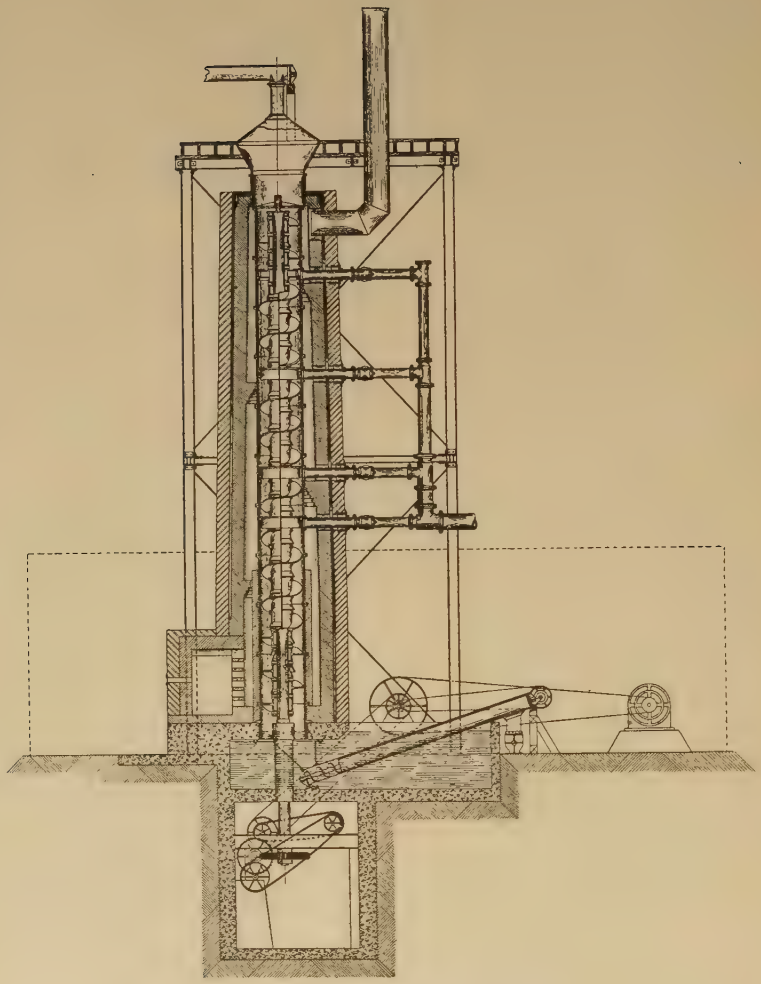

Fig. 26.—Colorado continuous retort.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Distillation Products Company, 909 Monadnock Bldg., San Francisco, Cal.	Near Casmalia, Cal.	S. H. Corfield.	The Corfield tapered-side retort uses the down-draft burning process. In the design of plant in operation 24 one-ton retorts are revolved on a turntable, one complete revolution of which in two hours is the time needed to burn the charge of one retort. When a retort has completed its cycle, it is inverted, dumped clean, reverted, filled, lighted, and operated as before. Each retort is connected to a suction pipe under control and the whole apparatus revolves around a large suction pipe.
Fuel Products Corporation, 110 W. 40th St., New York, N. Y.	New York, N. Y.	Whitaker-Pritchard.	This process was developed primarily for wood distillation; but it has been proposed for use in the pyrolysis of kerogenous shales and has been employed experimentally for that purpose (see Pritchard, Chem. Met. Eng., 23 (1920), 664). The uncondensible vapors from retorting are returned to the retort mechanically and passed through the distilling mass. In this way it is claimed that the heat units are distributed through the mass and vapors formed are carried out as rapidly as desired.
General Education Company. Colorado Springs, Colo.	Clay City, Ky.	J. H. Scott (U. S. Patents Nos. 1,115,453, and 1,198,069).	The Scott retort is of the vertical type, provided with either continuous or intermittent feed. The oil shale is preheated before entering the retort, and this preheating is said to be the main patented feature. It is reported by the Detroit Testing Laboratory, the engineers for the owners, that a temperature not exceeding 900° F. is required, that superheated steam will be used in practice, and that the retort can be fired with excess gas from the operation. A 50-ton unit, consisting of eight retorts, was to be installed at Clay City, Ky., but has never operated.

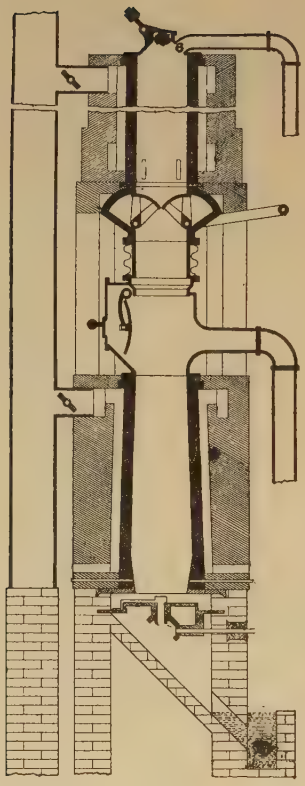

Fig. 27.—Scott retort.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Hartman Syndicate Co., Ashland, Oregon.	Ashland, Oregon.	Hartman Rotary Continuous Retort.	Vertical retort of complex type consisting of a series of twelve horizontal heated decks with moving mechanism in the shale space to spread shale on each deck and drop it to a lower deck. Steam is injected into lower decks. Retort is heated externally. (See Chem. Met. Eng. of June, 1925, for comments on this process.)
Industrial Process Engineering Company, Inc., Suite 508-511, Rialto Theater Building, St. Louis, Mo.	West First Ave. and Santa Fe Drive, Denver, Colo.	G. McD. Johns.	The Johns retort (capacity, 10 to 12 tons per 24 hours) consists of an inclined hearth or floor, about 3 ft. wide and 20 ft. long, constructed of carborundum tile. Ten in. above this the top is made by supporting sheet iron on angle irons, which, in turn, rest on the brick walls of the retort chamber. The top is sealed with a sand-fill and the products of destructive distillation are removed by conduits in the top. Oil shale, which has been pulverized so that 50 per cent. of it passes a 100-mesh screen, is fed in the upper end of the retort and is carried across the hearth by a scraper system. The spent shale is discharged at the lower end of the retort through a water-seal.
Jenson, J. B., 823 McIntyre Bldg., Salt Lake City, Utah.	Salt Lake City, Utah.	Jenson.	The "Jenson stage eduction process" uses a retort which is made up of three special cast-iron tubes, placed horizontally one above the other and communicating at alternate ends. Oil shale crushed to ½-in. size is fed into the upper tube and is conducted through the three consecutively by screw conveyors. The spent shale is removed by a screw conveyor through a water-seal. Each tube is provided with a separate take-off for the vapors and these are condensed separately. Heat is applied to the lowest tube and travels beneath the other two.

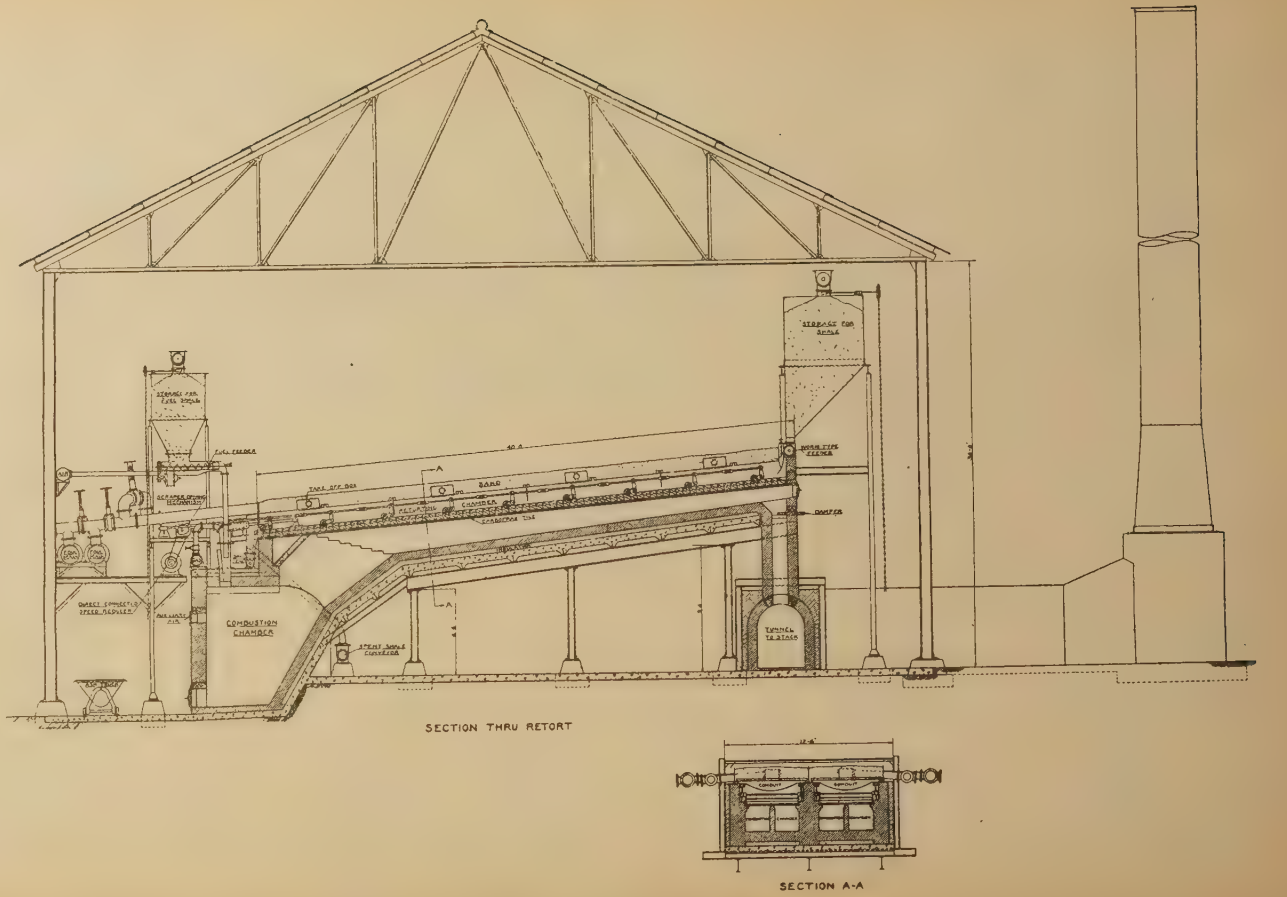

Fig. 28.—Sections of the retort, Johns' process of oil eduction.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Monarch Shale Oil Company, 722 Symes Bldg., Denver, Colo.	On Conn Creek, thirteen miles north of De-Beque, Colo.	The J. H. Ginet shale eduction process, controlled by The Ginet Shale Eduction Process, Inc., Temple Court Bldg., Denver, Colo. (U. S. Patent No. 1,371,160).	The Ginet retort is a cylinder of ⅞th in. cast iron, 3 ft. in diameter and 25 ft. in length, set horizontally in a brick oven. Oil shale crushed to ½ in. or finer is fed in at the forward end and advanced through the retort to the discharge end by means of 24 internal shovels mounted on an 8-in. iron-pipe shaft running through the center. The products of retorting are removed through a series of 39 outlets in the top of the retort, and heating is effected by oil-burners. A large bustle pipe collects the gases and vapors from the retort outlets and conducts them to the condensers. For a descriptive account of the Ginet process, see Shale Rev., June, *1921,* 3 and 10; and Mt. States Min. Age, May, *1921,* 15.
Mt. Logan Oil-Shale Mining and Refining Company, De-Beque, Colo.	Mt. Logan, north of De-Beque, Colo.	Simplex.	The retort (an 8-ton unit) consists of a slightly inclined flat hearth, about 30 ft. long and 3 ft. wide, made in segments of cast iron. The air-tight retort chamber is about 3 in. high and the lid is penetrated by five large take-off pipes, to remove the vapors. Finely crushed oil shale is fed into the upper end of the retort by a screw conveyor and is moved over the heated hearth in a thin layer by the aid of fifteen geared agitating arms or rabbles attached to a vertical spindle rotated outside of the retort. The spent shale is removed from the lower end of the retort through a seal.

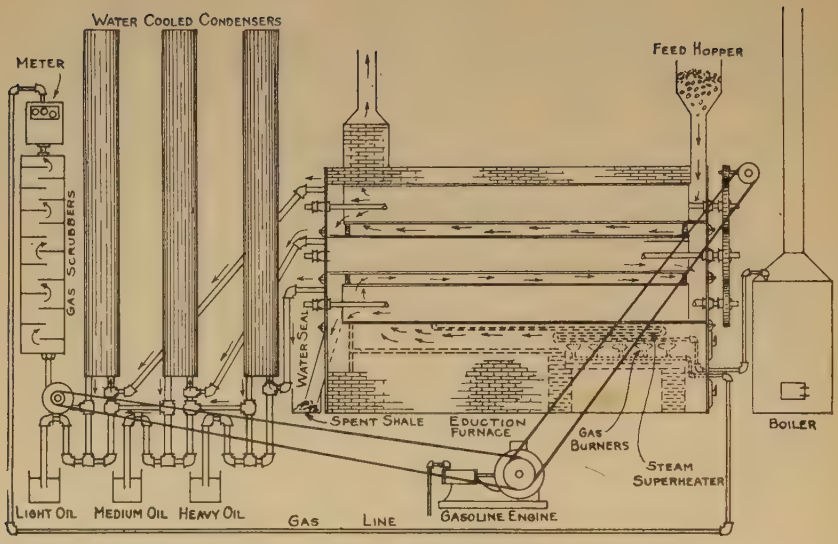

Fig. 29.—Jenson eduction plant. Flow-sheet of experimental plant, showing cylinders and condensers parallel-connected, in operation at Salt Lake City, Utah.

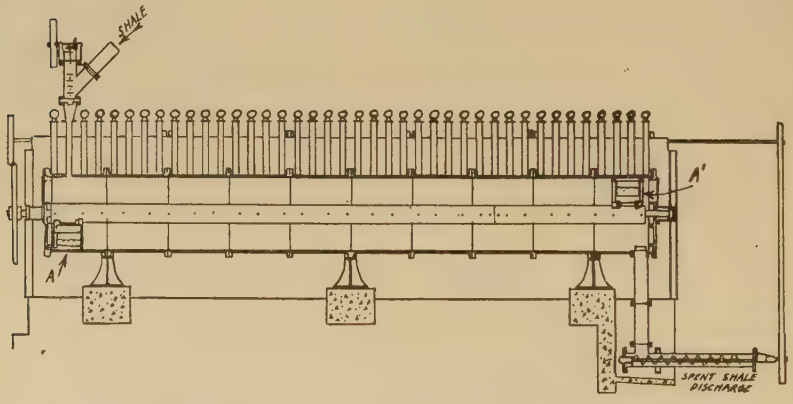

Fig. 30.—Sectional outline of the Ginet retort. The shale chamber is 25 feet long and 3 feet in diameter and has a capacity of 2½ to 3 tons of shale per hour, depending upon the mesh and character of shale treated. Typical shovels, located internally and provided with adjustable flanges for effecting agitation, are shown at *A* and *A'*.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
National Oil Machinery Corporation, 1270 Broadway, New York, N. Y.	York, Pa.; and Bush Terminal Bldg., Brooklyn, N. Y.	Ryan (U. S. Patent No. 1,327,572). On this process, see Hoskin, Proc. Colo. Sci. Soc., 11 (1921), 320.	In this process, finely divided oil shale is heated with heavy oil in a retort, the mixture being agitated. Some light oil is volatilized during the heating and the vapors are led off and condensed. The remaining products of the digestion, while still heated, are drawn off into a relatively large bath of light oil in which a rising current is maintained and liquid is withdrawn from the bath near its upper surface. Insoluble nonbituminous constituents are withdrawn from the bottom of the bath and heated to volatilize and recover the light oils with which they are impregnated. The liquid withdrawn from the bath is fractionally distilled.
National Retorting and Refining Corporation, 42 Root Bldg., Buffalo, N. Y.	Buffalo, N. Y.	National rotary of J. B. Newbery.	The National rotary retort is composed of an upright cylindrical shell inclosing a circular case revolving on roller bearings and surrounding ten hollow circular shelves, the interior part of which is subjected to the heat produced in the firebox beneath the retort. The retort is surmounted by a hopper with positive feed which will supply shale to the retort without allowing the gases to escape. On each shelf, attached to the inner walls of the revolving case, are twenty-four rotors which push and agitate the shale around on the shelves, making a complete revolution before the shale falls through a slot or hole to the next shelf. All shelves contain one slot or hole each, staggered, so that the shale makes a complete revolution before dropping to the next shelf.

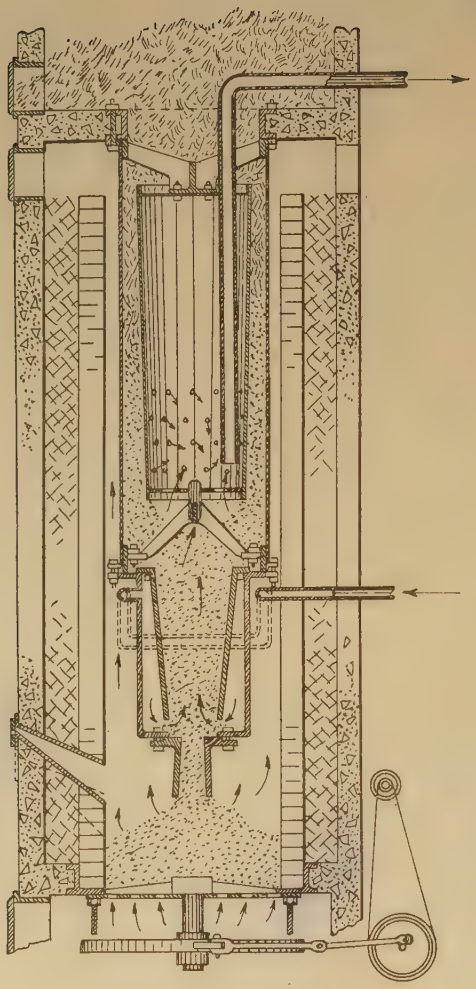

Fig. 31.—Chew retort.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
National Shale Oil Company, 18th and Blake Sts., Denver, Colo.	Denver, Colo.	Chew.	This vertical retort consists of an outer sheet-steel cylinder, about 12 ft. high and 3 ft. in diameter, drawn to a flat funnel shape at the bottom and set in a brick fireplace. Inside this shell is suspended a specially shaped metal drum, about 2½ ft. in diameter and 15 in. shorter than the shell. The inner drum is sealed at the bottom, except for an exit tube for the products of distillation. Oil shale crushed to about ¾-in. size is fed from a hopper at the top and passes down through the space between the inner drum and the outer shell and drops on the sloping hearth formed by the bottom of the outer shell. Heat from the burning spent shale passes up under the hearth and then up along the outside of the shell, heating the oil shale inside.
N-T-U Company, Santa Maria, Cal., and Gotham National Bank Bldg., New York, N. Y.	Stokes ranch, near Schuman Cut, Cal.	Dundas and Howes (U. S. Patent No. 1,469,628).	The process in use is a down-draft producer. The retort, which is 24 ft. high and 11 ft. in diameter, has a 6-in. brick lining and is fitted at the top with a charging door. The whole bottom moves laterally in or out of position for discharging; it is simply an inclosed grate with a suction nozzle coming out of the side of it which fits into a 10-in. pipe going to the condenser, then into a gas exhauster. After charging the retort, the gas exhauster is started, a fire is made on the top, and the door is closed. Air and noncondensible gas are mixed and admitted in the top, and 24 to 36 hours are required to burn the charge. Two charges a week are now being retorted in a 40-ton plant, which is intended to be the first unit of a 1,000-ton installation.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Porter Process Company, 409 Symes Bldg., Denver, Colo.	Power-house, Colorado School of Mines, Golden, Colo. A smaller plant is installed in the laboratory of the company, in Covington, Ky.	J. S. Porter.	The Porter 50-ton retort is of the oval-vertical type and is 1 ft. in diameter and 15 ft. in height. Oil shale, in 1-in. pieces, is moved through it by gravity and agitation, and steam is used to produce ammonia in the lower part of the retort. Water-gas made from spent shale is used as fuel and is burned at the bottom of the retort. The retort is divided into four different heat zones, in each of which there is a stirring device. In the two upper zones the heat is not allowed to exceed 700° F., while in the two lower sections the temperature is increased to 1000-1200° F.
Rocky Mountain Refining Company, Colton, Utah.	In Kyune cañon, east of Colton, Utah.	Debrey.	The Debrey retort consists of a vertical iron cylinder, about 12 ft. in height, in which there is an inner core for the injection of steam. The retort is heated by burning oil shale in two small furnaces on the sides of it. Oil shale is fed in at the top and spent shale is removed directly through a water-seal at the bottom.

Fig. 32.—Forty-ton retorting plant of the N-T-U Company, showing trestle and track from quarry.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Smallhorn Oil and Shale Refining Company, Dillon, Mont.	Near Dillon, Mont.	J. H. Galloupe (U. S. Patent No. 1,365,822). On this retort, see Shale Rev., *2* (1920), Nos. 8, 9.	The retort, which is made of cast iron and is about 20 ft. high, consists of two main parts, viz., an outer stationary shell, and an inner core constructed to revolve and carry the oil shale down through the retort. The outer shell is cast in segments 1 ft. high, having on their inner sides a series of staggered shelves projecting about 4 in. into the center. The inner core consists of a segmented, hollow cylinder with staggered fins projecting about 4 in. on the outside. When the retort is in operation, the core is suspended on ball bearings and revolved so that the finely crushed shale, which is fed continuously at the top, is scraped from each shelf to the one below by the fins of the core.
Southern Pacific Railroad Company.	Elko, Nev.	Pumpherston.	The retort was designed after the type used successfully by the Pumpherston and Oakbank companies in Scotland (English Patent 7113 of 1895), and described in detail in Bacon and Hamor's "American Petroleum Industry," *2*, 819-22. The retort at Elko was about 30 ft. in height, with a diameter of 2 ft. at the top and 3 ft. at the bottom; the upper 10 ft. was of cast-iron and the lower 20 ft. of firebrick. It was used for only a short time, and has been dismantled.

Fig. 33.—Oil-shale retort of the Southern Pacific Railroad Company at Elko, Nevada.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Stalmann, Otto B., 319 Ness Bldg., Salt Lake City, Utah.	University of Utah, Salt Lake City, Utah.	Stalmann-Wells. On this retort, see Hoskin, Proc. Colo. Sci. Soc., *11* (1921), 315.	The Stalmann retort is of the vertical type, and is 1½ ft. in diameter at the top, 2¼ ft. in diameter at the bottom, and 18 ft. in height. It is charged with oil shale broken to pass a 6-in. screen and the column of shale is kept in motion by means of a turntable which acts as a discharger at the bottom of the retort. Gas produced during retorting is used as fuel. As in the case of other retorts, the temperature in retorting varies with the character of the oil-shale. It is usually between 600° and 850° F. at the bottom.
Troy-American Petroleum Corporation, 1214 First National Bank Bldg., Denver, Colo.	Wheeler Gulch, near DeBeque, Colo.	Wingett.	This vertical retort is 35 ft. in height and 24 ft. in circumference; it is provided with automatic feed and discharge, and 20-mesh oil shale is moved through it by a screw propeller and a rake system. Crude shale oil and fixed gas from retorting are used for fuel, and the temperature is maintained at about 680° F.
Trumble Oil Shale Cycle Co., Alhambra, Calif.	Alhambra, Calif.	Trumble Oil Shale Cycle Distillation Plant	Old type vertical retort with no internal device or moving parts. Shale in the retort is heated by the vapors from an oil-cracking still, heating being assisted by injection of superheated steam. Vapors from retort pass to partial condenser, where heavy oil is condensed and run to cracking still. A second condenser cools vapors to give a light condensate which after re-distilling is said to be ready for marketing. Spent shale is claimed to be used in a gas producer and resulting hot gases used to preheat shale to 400° F. before it enters distillation retort.

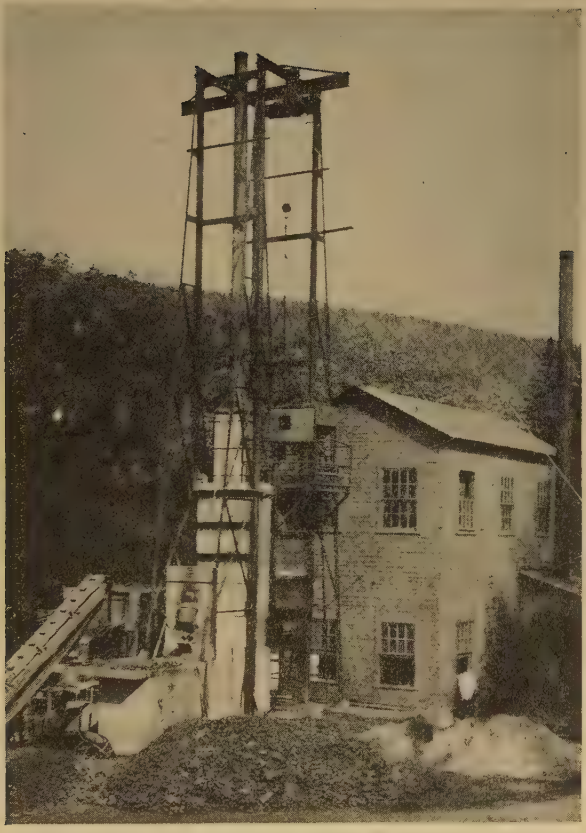

Fig. 34.—View of the Wallace plant at Rosevale, N. B., Canada.

Name and Address of Company	Location of Experimental Plant	Name of Retort or Retorting Process	Description of Process of Retorting
Wallace Coke, Oil and By-Products Company, 412 Missouri Ave., East St. Louis, Ill.	On White River, near Watson, Utah; another at Rosevale, Albert Co., N. B., Canada.	G. W. Wallace (U. S. Patents Nos. 1,283,000, 1,283,001, 1,358,662, and 1,358,664). The plant of the Ute Oil Company is being completed by the Russell Engineering Company, of St. Louis, Mo.	The retort on the property of the Ute Oil Company (of 714 Wainwright Bldg., St. Louis, Mo.), ten miles north of Watson, Utah, consists of an outer cast-iron chamber, about 14 ft. in length and 15 in. in diameter, into the center of which is inserted from the bottom a perforated tube for withdrawing the vapors. The retort is set vertically in a brick furnace, into which the permanent gases from retorting are forced for fuel. The Wallace retort at Rosevale, N. B., is 11 ft. high over all, including bottom and top mouthpieces, and takes a charge of oil shale 8 ft. 6 in. high. The cross-section of the retort at the center measures 14 in. by 30 in., the full taper in 11 ft. being 4 in. The area of the working surface is 63.24 sq. ft. and it is said that in excess of 5 lb. of oil shale may be retorted per sq. ft. per hour at a temperature of 1100° F. All the products of distillation are withdrawn inwardly into a central collection chamber, from which they immediately escape. It is stated that the temperature of formation is probably the highest temperature to which any of the oil vapors are subjected at any stage of the process of retorting.
Western Shale Oil Company, Grand Junction, Colo.	Near Watson, Utah.	J. H. Galloupe (U. S. Patent No. 1,365,822). Four 10-ton retorts have been completed nine miles from Dragon Station, near Watson, Utah. A retort is being erected in the Willow Creek district, about forty miles west of Watson.	See descriptive note given *supra*, under Smallhorn Oil and Shale Refining Company.

Fig. 35.—Plant of the Ute Oil Company, near Watson, Utah, showing two nests of eighteen Wallace retorts; this plant to have a throughput of 300 tons per day.

Several other processes, devised since the recent awakening to the future commercial possibilities of oil shale, have attained the experimental-plant stage, but operations therewith have been discontinued. For example, a plant designed by the late Arthur L. Pearse, and capable of retorting some 20 tons of oil shale per day, was erected at Cresson, Pa. This trial of the "Pearse process" was said to have been successful, but at present the work is not in progress. Then, too, the Rainbow Petroleum Products Company, of Salt Lake City, Utah, put up a unit plant to demonstrate the process of E. T. Erickson (U. S. Patent No. 1,281,320), which has been closed for some time on account of prevailing economic conditions.

It cannot be predicted, of course, just which, if any, of the processes listed *supra* will endure and assume future industrial importance. How-

ever, there is no doubt that, once begun soundly, the shale-oil industry will be in the control of substantial and large organizations that are provided with strong technical staffs. As has been the case in Scotland, the companies of small proportions, unable through lack of capital to conduct adequate research and development and to expand to the size essential for profitable operation, eventually will dissolve.

CHAPTER 11

ABSTRACTS OF SHALE OIL ARTICLES

By

Ernest E. Lyder (–1920)
Ralph T. Goodwin (1921)
Ralph H. McKee (1922–)

1—DIETRICH, P. F. Descriptions of the French Shale Deposits. Paris, 1786-1799.

2—GILLET-LAUMONT. Upon the Bituminous Schists and Sandstones cited in the Memoir of Leschevin. J. des Mines, *33,* 46-52 (1813).

3—PAYEN, ANSELME. Note sur les Schistes Bitumineux et le Lignite d'Ardes. Ann. Chem. Phys., 2nd ser., *29,* 335 (1825).

Shale, carbonized and reduced to powder, becomes intense black. Carbon contains some ferrous sulfide. Shale contains lignite which gives carbon mixed with bright particles. Fragments of lignite extracted from shales are hard, lined, and flattened from weight which they have supported.

4—ANDERSON, G. Description of Bituminous Rocks which occur in Rossshire in the Neighborhood of Inverness. Edinburgh J. Sci., *4,* 93-95 (1826).

Brief note only.

5—LAURENT, A. Sur les Schistes Bitumineux et sur les Paraffins. Ann. Chim. Phys., 2nd ser., *54,* 392-396 (1833).

6—LAURENT, A. De l'Huile des Schistes Bitumineux d'Autun et de Quelques Prodits Qu'on en Obtient. Acad. des Sci., Bull. No. 24 (1837).

Distillation of these shales produces an oil tested as follows: boiling between 80° and 85° C., purified with sulfuric acid and caustic gave a product with properties of a naphtha. Boiling between 120° and 122°, about same as above. Boiling at 169°, much the same, soluble in alcohol and ether, carbon 85.6%, hydrogen 14.4%. Boiled with nitric acid the 80°-85° fraction became soluble in H_2O, alcohol, and ether and concentrated acid formed product soluble in alkalies.

7—SELLIGUE, M. Emploi de l'Huile Extraite des Schistes Bitumineux pour la Fabrication du Gas d'Eclairage. Compt. Rend., *4,* 969-970 (1837).

Analysis of shale oil gases from the destructive distillation of shale oil.

Carbonic Acid	.20%
Oxygen and Nitrogen	Trace
Ethylenes	25.30
Methane	69.80
Hydrogen	3.05
Carbon Monoxide	6.65

8—BERTHIER, P. Analyses of some French Bituminous Minerals. Ann. Des Mines, 3rd ser., *13,* 605-16 (1838).

9—LEFEBURE. The Bitumen Mines of Bastennes and Gaujacq (Landes). Ann. des Mines, 3rd ser., *13,* 585-94 (1838).

10—BERTHIER, P. Analyse des Schistes Bitumineux d'Autun. Ann. des Mines, 3rd ser., *13,* 616-618 (1839).

Shales are leaflike. Have grainy fracture, grayish tint. On distillation give a great deal of water. Oil quite thick and color dark brown. First oils very

fluid and can be used for gas making. Residue is black earth-like material and could be used to decolorize syrups. Shales burn with smoky flame and give strong odor of bitumen. Are not very combustible. Are not attacked by alcohol or ether. Caustic takes out only small quantities of alumina and silica. Strong sulfuric does not attack bitumen.

11—SELLIGUE, M. Procédé pour la fabrication d'un gas d'eclairage au moyen des huiles provenant de la destillation des certains schistes bitumineux. Compt. Rend., *10,* 861-5 (1840).

12—ELSNER, L. Upon the Composition of Shale Oil. Verh. Ver. Beford. Bewerbfl. Preuss., *24,* 195 and 1916 (1845).

13—DELAHAYE, N. B. Sur les Schistes de Muse. Bull. Geol. Soc., France, 2nd ser., *5,* 304-308 (1848)
Discusses nature of the shales.

14—ST. EVRE, EDOUARD. Note sur Divers Hydrocarbons Provenant de l'Huile de Schiste. Compt. Rend., *29,* 339 (1849).
Fractionation products of distillation of oil are treated with sulfuric acid, purified by repeated distillations with fused potash and anhydrous phosphoric acid. Author claims to have isolated hydrocarbons represented by formulas:

$C_{72}H_{68}$	boiling	at	275°-280°
$C_{56}H_{52}$	"	"	255 -260
$C_{52}H_{48}$	"	"	215 -220
$C_{36}H_{36}$	"	"	132 -135

15—BOURGÒT. Note sur le Goisement des Schistes Bitumineux à Impressions de Vegetaux de Menat. Sur le Chaleur Presumable d'un Dyke Basaltique, non Venu au Jour au Point où une partie de ces Schistes a été transformée en Tripoli par la Chaleur Souterraine; Considerations Generales sur ce Sujet. Soc. Geol. France, Bull., *8,* 39-44 (1850).

16—DELAHAYE, N. B. Facts and Observations connected with the History of Bituminous Shales. Rev. Sci. Ind., *38,* 1-17, 49-63, 97-100, 161-74, 225-32, 321-9, 337-52, 440-47 (1850).

17—ANON. The Torbanhill Mineral Case. The Chemist *1,* 43-49 (1854).
Summary of chemical evidence presented in case of Elizabeth H. Gillespie against James Russell and Son.

18—ANON. The Torbanhill Mineral Case. The Chemist *1,* 125-126 (1854).
Discussion of the Torbanhill Mineral Case, giving opinion of German scientists.

19—HERAPATH, T. J. The Torbanhill Mineral Case. The Chemist *1,* 2207-208 (1854).
Letter discussing legislation on Torbanhill Mineral, giving analysis of mineral and opinions as to its character and composition.

21—WILLIAMS, C. G. On the presence of Pyridine in Naphtha among the Volatile bases in Naphtha from the Bituminous Shale of Dorsetshire. Phil. Mag., 4th ser., *8,* 209-212 (1854).
Describes chemical work on pyridine in naphtha of shale oil of Scotland.

22—WILLIAMS, C. G. On the Volatile Bases Produced by Destructive Distillation of the Bituminous Shale of Dorsetshire. J. Chem. Soc., *7,* 97-107 (1854).
Gives analysis of shale oil. Different organic bases found in shale oils mentioned and methods of identifying same.

23—TRAILL, T. S. On Torbanhill Mineral. Roy. Soc. Edinburgh, *21,* 7-13 (1857).
Torbanhill mineral, called by author bitumenite, was examined and yielded paraffin, petroleum, and gas. Color blackish brown. Structure massive. Principal fracture flat, conchoidal, inclining to splintery; cross fracture uneven and slatey. Examined by strong light edges are translucent reddish-brown. Streak pale ochre-yellow hue. Sp. Gr. 1.284. Inflammable; does not melt. Volatile 84.1%, solid residue 15.9%. Occurs in beds 16 to 24 inches thick.

24—WILLIAMS, C. G. On Some of the Products of the Destructive Distillation of Boghead Coal. Phil. Trans., 447-62 and 737-45 (1857).

25—BARLOW, J. On mineral candles and other products manufactured at Belmont and Sherwood. Proc. Roy. Inst., *2,* 506 (1858).

26—DESBRIEF, P. Schistes Bitumineux des Environs d'Autun. Ann. des Mines, 5th ser., *14,* 44 (1858).
Brief note on yield of oil from shales of Autun, France.

27—GUILLEMIN, E. Combustible Shale from the Migri District in the Caucasus. Bull. Soc. Imp. Nat. Moscow, 325-8 (1858).
Letter including analysis of bituminous shales from the Caucasus.

Volatile	31.44%	Moisture.	5.50%
Fixed Carbon.	20.16	Bitumen..	7.00
Ash	48.40	Gas	18.94

28—WAGENMANN, P. Upon the new Scotch raw material for Burning Oil and Paraffin Manufacture. Dingler's Polytech. J., *151,* 116-19 (1859), and *152,* 113 (1859).

29—ANISELL, THOMAS. Pyrogenic or Hydrocarbon Oils. New York (1860).
Introductory chapter is a splendid history of distillation of shales, coals, etc., both in Europe and America.

31—GESNER. A Practical Treatise on Coal, Petroleum and other Distilled Oils. First Ed., p. 34 (1861).

32—HOWELL, H. H., and GEIKE, A. Geology of the Neighborhood of Edinburgh. Mem. Geol. Survey Great Britain, 28, 39, 46 and 116 (1861).

33—FERRARRIO, O. Chemical Analyses of the Bituminous Schists of the Valley of the Setarolo. Atti. R. isti. Lomb., *3,* 15-18 (1862).

34—LAHORE. Apparatus for the Distillation of Asphaltic Shales. Gen. Industri., *24,* 304-8 (1862).

35—MASTON and PARISOT. The Bituminous Schists of Froid-Fontaine (1862).

36—ROYER, M. E. Essai sur la Constitution Chimique de l'Huile de Schiste. Soc. Sci. Phys. Nat. Bordeaux Mem., *2,* 285-292 (1862).
Ultimate analyses of shale oil: carbon 85.71%, hydrogen 14.20%. Concentrated sulfuric acid on oils gave a sulfonated residue reddish-brown in color similar to sulfo-vinates. Nitric acid oxidized partially to oxalic acid. Analysis of different fractions:

Fraction	1	2
Boiling Pt.	130°	130°
Carbon	86.10	86.49
Hydrogen	13.68	13.51

Fraction	3	4	5
Boiling Pt.	195°	200°	200°
Carbon	86.05	86.02	86.40
Hydrogen	13.62	13.62	13.59

Formula thought to correspond to C_nH_{n-1}.

37—Anderson, G. On the Occurrence of Bituminous Shales in Mountgerald (Scotland). London Geol. Soc. Quart. J., *19,* 522 (1863).
Brief mention of shale near Mountgerald, Scotland.

38—ANDRÄ, C. J. Fossil Fuel from New South Wales (Kerosene Shale). Naturhist. Ver. Preuss. Rheinl. Verh. 32 Sitzungsber, p. 5, (1863).
Gives results of distillation of sample of kerosene shale sent from Sydney, New South Wales.

39—HUNT, T. STERRY. On the Chemical and Geological History of Bitumens and Bituminous Shales. Am. J. Sci., 2nd ser., *35,* 157-171 (1863).
Suggests that oil shales be called phroschists. Discusses shale occurrences in various geological formations and gives proximate analyses. Also discusses bitumens and their probable constitution.

41—VOHL, E. H. L. Ueber die Producte der Trockenen Distillation des Rheinishen Blatterschieffers (Schiste Bitumineux) der Sachsischen sowie der Thuringischen Braunkohle. Ann. Chem. Pharm., *68,* 504-508 (1865).
A discussion of the products recovered by the dry distillation of bituminous shales giving yield and properties of oil.

42—CLARKE, W. B. On the Occurrence and Geological Positions of the Oil Bearing Deposits of New South Wales. London Geol. Soc. Quart., *22,* 439-448 (1866).
Short discussion of age of oil shale and cannel coals of New South Wales.

43—LUNGE, G. The Paraffin Oil Plant of Young. Dinglers Polytech. J., *181,* 456-62 (1866); Ann. Gen. Civ., 7, 57 (1868).

44—MAGNIER, M. D. New Complete Manual for the Manufacture and Use of Mineral Oils. Paris (1867), 18mo.

45—SIMONIAN, L. Sur les Schistes Bitumineux de Vagnas (Ardèche). Compt. Rend., *64,* 1138-1185 (1867).
Brief description of the occurrence and distillation of oil shale in France.

46—TAYLOR, ANDREW. On the Bituminous Shales of Linlithgowshire and Edinburghshire. Phys. Soc. Edinburgh Proc., *3,* 16-24 (1867).
Discusses geologic relations of Scottish oil shales.

47—JOFFE, J. Sur L'Analyse de Combustibles Mineraux Nouvellement Exploités en Ecosse. Bull. Soc. Chim. Paris, 2nd ser., *10,* 8 (1869).

48—TAYLOR, ANDREW. Scotch and Welsh Mineral-Oil Trades. Edinburgh Geol. Soc. Trans., *1,* 19-20 (1868).
Mentions experiments by Clayton in 1728-29 distilling carbonaceous materials at low red heat.

49—HARTT, C. F. Geology and Physical Geography of Brazil. Boston and London, 1870.
Mentions shale from Bahia yielding large amount of oil on distillation.

51—CHOSSON. De la Situation de L'Industrie des Schistes Bitumineux du Bassin d'Autun. Ann. des Mines, 6th ser., *20,* 347-428 (1871).
Report dealing with whole situation of shale industry giving connected legislation. Also kinds retorts used. No plants in France before 1843. In 1861 some 1700 metric quintals of shale produced. In 1863, 848,500 quintals produced. Crudes sold at 35 francs per hectoliter and burning oil at 65 francs. In 1864, 1,285,500 quintals produced yielding 47,500 liters of oil. Importation of American oil almost destroyed industry. By 1867 crude oil was 18 francs and burning oil 35 francs. Description given of processes of working shales in various concessions. First retorts were rotary type 1 meter and 75 cm. in diameter, heated externally and held a cubic meter of shale. Yielded 50 liters of oil per ton and cost of operation was about 5 francs per cubic meter of shale. Vertical retorts later introduced. Rectangular in shape, 1 meter 68 cm. high and 1 meter and 30 cm. long, by 30 cm. wide. Charge distilled in 24 hours. One cubic meter of shale gave 40 liters of oil, density 0.858. Describes process of fractionating and refining oil. Another type of retort introduced was vertical formed by two concentric cylinders. Shale passing between them. Numerous data given on refining and improvements in retorts.

52—GALLETLY, J. A Paraffin Having a High Melting Point. Chem. News, *24,* 187-8 (1871).

53—TOURNAIRE, M. De L'Industrie des Huiles de Schiste dans L'Autunois. Ann. des Mines, 6th ser., *20,* 429-474 (1871).
Geology of Autun basin and distillation tests of various shales. Describes shale retort used. The retort is vertical, rectangular and non-continuous. Following table shows how industry developed.

Year	Cubic Meters of Shale Dist'd	Crude Oil Hectoliters
1860	.....	17,440
1862	63,600	28,258
1864	102,217	54,539
1866	86,815	47,431
1868	81,519	35,691
1869	100,417	.....

Hectoliter of crude oil valued at 15-16 francs. Other obsolete data given, such as products recovered and distillation methods.

54—GREENWELL, G. C., and BINNEY, E. W. Kerosene Shale, New South Wales. Trans. Manchester Geol. Soc., *11,* 63-70 (1872).
Discussion of bituminous materials from New South Wales. Samples yielded 160 gallons of oil per ton.

55—MAYER, J. The Mineral Oil Industry of Scotland. Mining Mag. Rev., *1,* 118-28 (1872).

56—TAYLOR, ANDREW. On Bitumen, Oil Shales and Oil Coals. Edinburgh Geol. Soc. Trans., *2,* 187-189 (1873).
Brief mention of Scottish oil shales.

57—ANDRÄ, C. J. Allgemeine Ueber Einen Paraffin Enthaltenden Fossilen Brennstoff von Hartley in Neu Sud Wales. Verhandlungen des Naturhistorischen Vereines der Preussischen Rheinlande und Westfalens, *32* (Sitzungsber.) 5 (1875).

Short description of kerosene shales of New South Wales.

58—COLEMAN, J. J. The Effects of Pressure and Cold upon the Gaseous Products of Distillation of Shale. Trans. of Chem. Soc., *28,* 856 (1875).

Gases from retort resembles coal gas. 467 liters passed through liquefying apparatus gave at –5°, 54 cc. of sp. gr. .690 at 16° C., and at –18°, 33 cc. of sp. gr. .650 at 16° C. In average of three experiments gas yielded one gallon of liquid per thousand cu. ft. Gas lost illuminating power after removal of liquid products. Proposes scheme for recovery of liquid products by compression and cooling.

59—NEWTON, E. T. On Tasmanite and "Australian White Coal." Geol. Mag., *11,* 337-42 (1875).

61—WINDAKIEWICZ, E. Ueber die Wichtigkeit des Vorkommens von Bituminosem Schiefer in Galizien. Oesterr. Z. Berg. Huttenw., *23,* 196 (1875).

62—DORN, KARL. Shale Deposits and Their Use as Fuel. Tübingen, 1877.

Describes "the first practical shale-burning furnace."

63—NEWBERRY, J. S. On the Discovery of Mineral (Ozokerite) Wax in Utah. Am. Sci., 3rd ser., *17,* 340-341 (1879).

Mentions oil shales high in paraffin in central Utah.

64—ROBINSON, G. C. New Bases of the Leucoline Series, Part I. Trans. Roy. Soc. Edinb., *28,* 561 (1879).

Author examined purified fraction of Scottish shale oil bases (obtained from Young's Paraffin Works) from which portion boiling below 315° C. was previously removed by 12 fractionations. Mixture fractionated three times and divided into two parts, portion A, 305-320° C., and portion B, above 320° C. Attempts to form crystallizable salts of the double chlorides of Pt, Au, Cd, Hg, Pb, and Zn failed, only sticky resinous masses being obtained. Portion A fractionated twenty-five times; one-third now appeared below 270°, one-third from 270-280°, and the remainder between 280-295°. Portion B treated similarly. Fraction 290-295° C precipitated with $PtCl_4$. Analysis of compound indicated the presence of new base $C_{12}H_{13}N$. 100 gm. of mixed base treated with 200 gm. of CH_3I and product fractionally crystallized. Fractions treated with $PtCl_4$ and HCl and analysed for Pt content. Results indicated presence of new bases $C_{12}H_{13}N$, 270-275° C., $C_{13}H_{15}N$, 290-295° C., and $C_{14}H_{17}N$, 310-315° C. Bases when newly distilled nearly colorless, rapidly darkening on exposure to light and air. Gave no blue color with amyl iodide and KOH, showing them to be members of the leucoline and not the vinoline series.

65—BONG, X. G. Sur les Residus de la Fabrication des Huiles de Schistes. Bull. Soc. Chim. Paris, 2nd ser., *34,* 147-149 (1880).

Solid Residues. Mineral residues have following composition:

Carbon	5.65%
Iron Oxide	3.55
Alumina	27.85
Silica	63.55
Magnesium Oxide	1.00
Potash	4.00
Phosphates	6.00

May become a source of lithia. Acid tars contain phenols.

66—ROBINSON, G. C., and GOODWIN, W. L. New Bases of the Leucoline Series, Part II. Trans. Roy. Soc. Edinb., *29,* 265 (1880).

Working on a new supply of shale oil bases, fractions were examined as before, authors by analysis of Pt salts separated and identified five new members of leucoline series: $C_{12}H_{13}N$, 290-295° C; $C_{13}H_{15}N$, 325-330°; $C_{15}H_{19}N$, 345-350°; $C_{16}H_{21}N$, 360-365°. Fractions of higher boiling point examined but not analysed; probably consisted of $C_{17}H_{23}N$ in small quantity. Upper limit of bases as far as boiling points go was 390° C. Recently distilled bases were pale brown, rapidly darkening either when exposed to air or when allowed to stand in hermetically sealed tube. Salts do not crystallize. Authors suggest that bases be named in order from first member, leu-

coline, C_9H_7N, to the last member octacoline, $C_{16}H_{21}N$, as follows: leucoline, iridoline, cryptidine, tetracoline. pentacoline, hexacoline, heptacoline, and octacoline, respectively.

67—ROBINSON, G. C., and GOODWIN, W. L. New Bases of the Leucoline Series, Part III. Trans. Roy. Soc. Edinb., *29,* 273 (1880).
Methyl iodide forms addition products with bases tetracoline, pentacoline, hexacoline and octacoline, with first two at ordinary temperatures and with last two after digestion for some time at 100° C. Methiodide of tetracoline is pale yellow, of pentacoline olive green, and of octacoline brilliant orange.

68—ALLEN, A. H. On the Relative Proportions of Olefines in Shale and Petroleum Products. Analyst, *6,* 177-180 (1881).
Commercial products from shale differ from parallel series of products from well petroleum. Different proportions of olefines in respective oils cause differences in action of strong nitric and sulfuric acids. Paraffins or hydrocarbons of marsh gas series do not form additive compounds with bromine as do ethylene hydrocarbons. Analyses of many petroleum and shale oil fractions given.

69—CANAVAR, M. Gli Schisti a Fucoidi, e Gli schisti Bituminosi che Spesso Li accompagno Nell 'Appennino Centrale. Soc. Toscana Sci. Nat. Proc. Verb., *3,* 6, 7 (1881).

71—RICCIARDI, LEONARDO. Ricerche chimiche sopra una Lignite e Alcuni Scisti Bituminiferi di Giffoni Valle e Piana, Provincia di Salerno. Accad. Gioenia, Sci. Nat. Atti., 3rd ser., *16,* 123-128 (1882).

72—TERVET, R. Sulfur in Shale Naphtha. Chem. News, *45,* 98 (1882).

73—BAUMANN and SCHOTTEN. Pharm. Zentralhalle, *1883,* 447.
On the properties of ichthyol oils.

74—YOUNG, JAMES. Obituary and Biography. J. Soc. Chem. Ind., *2,* 233 (1883).

76—CAMERON, J. M. The Bituminous Deposits of the Camamu Basin, Province of Bahia, in the Brazilian Empire. London, 1884.

77—GRIFFITHS, A. B. Notes on the Recent Discovery of a Paraffin Shale Deposit in Servia. Chem. News., *49,* 107-108 (1884).
Notes shale in western Servia will burn with smokeless flame and yields paraffin on distillation.

78—BEILBY, G. T. Production of Ammonia From the Nitrogen of Minerals. J. Soc. Chem. Ind., *6,* 316-224 (1884); and in J. Roy. Soc. Arts., *33,* 313-320 (1885).
Work in increasing yield of NH_3 from shale and coal retorts. Analysis of shale showed NH_3 equivalent to 74.8 lbs. $(NH_4)_2SO_4$ per ton. Recovery was only 30 lbs. Broxburn shales contain 0.72% N_2. By heating to higher temperatures and for longer time than in oil distillations could recover all the N_2 as NH_3. Also steam helped. N_2 remained in residue as long as any carbon was present. Full current of steam converted all N_2 in shale into NH_3. Material containing 45% carbon takes three times as long to give all NH_3 as one containing 15% carbon. Could rid coal of N_2 by oxidizing in steam and air using excess of steam.

Crude oils of naphtha, artificially prepared by destructive distillation of carbonaceous deposits, contain N_2 in form of alkaloidal tars but most natural American petroleums contain no N_2. Basic tars of shale contain 20%-30% of original N_2 contained in shale. Distribution of N_2 of bituminous shales, distilled for production of paraffin oils, as follows: Of 100 parts N_2 contained in original shale as NH_3, in water distillate, 17%; in oil as basic tars, 20.4%; in residue or coke, 62.6%. Basic tars, separated from crude shale oil by treatment with 8% of diluted sulfuric acid, neutralized with soda and distilled gave in nine fractions:

1.	Water and volatile alkaloids lost.	
2.	100 gr.	3.54%N
3.	100 gr.	3.37
4.	60 gr.	3.35
5.	110 gr.	3.24
6.	60 gr.	3.47
7.	80 gr.	3.54
8.	50 gr.	3.35
9.	50 gr.	3.54
Residue	390 gr.	4.00

In distillation of shale the brown oil, consisting largely of alkaloidal substances, comes off last. Steam has been introduced after oil distillation is complete with satisfactory results. Certain amount of air mixed with steam induces a larger yield of oil richer in paraffin. Also reduces expense of steam; gives crispness to spent shale which facilitates removal from the retort. Disadvantages are (1) increase of incondensible gases; (2) air carries forward great quantity of light naphtha which, in order to recover, necessitates use of extensive oil scrubbers. Dr. Grouven contrived ammonia ovens for removal of N_2 from alkaloidal tars. Gives short discussion of Grouven-Young-Beilby process and its application to treatment of coal for gas and NH_3.

79—MURRIE, JAS. On the Processes Employed in Italy for the Extraction of Oils, etc., from Bituminous Rocks in that Country. J. Soc. Chem. Ind., *4,* 182 (1885).

Includes description of means of utilizing shales and bituminous sandstones in Pescara Valley, near San Valentino, Italy. Superheated steam retort designed by Wm. McIvor, of Young's works, Scotland, was built and handled material successfully, but industry was financial failure on account of high density and high sulfur content of oils, and high production costs. Lubricating oils manufactured said to lose viscosity very rapidly with rise of temperature.

80—BEILBY, GEORGE. On the Production of Ammonia from Nitrogen of Minerals. J. Soc. Chem. Ind., *3,* 216 (1884).

This is original paper advocating use of steam in retorting oil shale for purpose of increasing $(NH_4)_2SO_4$ yield. Details of these first retorts of this type and of results obtained given.

81—DAWKINS, W. B. On the Kerosene Shale of Mount Victoria, New South Wales. Rep. British Assoc. *1886,* 643 (1887).

82—GREEN, BURTON. Kimmeridge Shale, Its Origin, History and Uses. London, 1886, 8vo.

83—PINNO. Remarks upon the Occurrence and the Utilization of Boghead Coal and Oil Shale in Scotland. Zeitschr. Berg. Hutt. Salinenw., *34,* 129 (1886).

84—WEEKS, J. D. Mineral Resources of the U. S. 484-6 (1886); and 398-9 (1894).

85—KRAEMER, G., and BÖTTCHER, W. Relation between Petroleum and the Hydrocarbons of Coal Tar and Shale Tar. Ber., *20,* 595-609 (1887).

Examination showed that German petroleum as well as Russian (Baku) are not different in character from coal and shale tar, but only in relative proportions of hydrocarbons attacked and unattacked by concentrated sulfuric and nitric acid. Unattacked ones are paraffins and naphthenes and others, benzene and naphthalene derivatives according to author.

86—MILLER, A. K., and BAKER, T. Composition of Shale Spirits. Proc. Chem. Soc., *3,* 97 (1887).

Oil gas contained heptylene as highest hydrocarbon and all olefines possessed normal constitution. But shale oil contained olefines such as octylene and nonylene. Octylene gave heptylic acid and capronic acid, also acetic and formic acid were found.

87—STEUART, D. R. On the Occurrence of Petroleum in a Shale Mine at Broxburn. J. Soc. Chem. Ind., *6,* 128-130 and 352 (1887).

Notes semi-solid oil (sp. gr. 0.842) from bore hole 600 feet deep in vicinity of oil shale beds.

88—SKEY, W. Kerosene Shales. Colonial Museum Laboratories, New Zealand, 23rd Ann. Rept., pp. 50-51, 25th Ann. Rept., pp. 56-57, 29th Ann. Rept., p. 19, 31st Ann. Rept., p. 10 (1889-1898).

	From Wannate	From Mangonui
Fixed Carbon	9.81%	11.17%
Hydrocarbons (volatile)	27.99	33.18
Water	16.19	14.61
Ash	46.01	41.04

89—STEUART, D. R. Manufacture of Paraffin Oil. J. Soc. Chem. Ind., *8*, 100-110 (1889).

This is the best and fullest published description of the Scottish process of this date. Broxburn shale used. Analysis of shale: Carbon, 20%; Hydrogen, 3%; Nitrogen, .7%; Sulfur, 1.5%. Products of distillation.

Volatile	
Crude Oil	12%
Ammoniacal Water	8%
Permanent Gas	4%
	24%

Non-Volatile (Spent Shale)	
Combustible	9%
Ash	67%
	76%

For good quality crude oil temperature of distillation must be low, a red heat, invisible by day, faintly visible by night. High temperature gives heavy dark oil, more loss in refining, less solid paraffin, higher ammonia yield. Henderson's retort used at Broxburn. Temperature of oven is from 900-1000° F. Steam entering retort, 630° F. Shale inside retort 1½ ft. from top, three hours after charging, 630° F., 16 hours after charging, 730° F. Products of distillation at exit pipe, 500-600° F. Neither lime nor soda reagents had any effect on yield of ammonia or quality of crude oil. Steam used to advantage. Oil taken from retort at 2 hour intervals increased in sp. gr. from 0.863 to 0.888 and in setting point 78° to 87° F. Loss with oil of vitriol from 5½% in the beginning to 10% in middle, back to 5½% at end. Loss with soda gradually increased from 2.6 to 3.8%. Each ton of shale in the works gives 30 gals. NH_3 water, nearly 2000 cu. ft. permanent gas, which is sufficient to light works, fire retorts along with spent shale and help raise steam. Oil dark green, semi-fluid at ordinary temperatures. Sets at 80° F. Sp. gr. 0.865, sp. gr. of NH_3 water, 1.012. Contains NH_3 equal to 0.277 lbs. $(NH_4)_2SO_4$ per gal. principally in form of carbonate.

Present distillation system continuous. Tank-car shaped stills connected with coking stills. Stills charged (2000 gals.) and then fire lighted and when distillation commences oil is run into the central still. Oil travels length of the first still, "green naphtha" of 0.753 sp. gr. being distilled off. Undistilled oil carried to still 2, distilling off fraction of 0.835 sp. gr. From still 2 oil carried to coking still, still 3. Coking stills fired up gently before receiving hot oil. Each coking still remains connected in series for eight hours; then is disconnected and distilled to dryness by itself. Gravity of oil from coking stills 0.860-0.965. 35,000 gals. run per day. Steam passed into all boiler stills. Quantity of distillate can be controlled by adjustment of connecting pipes, by firing, and by steam. *General Refining Process:* The two fractions, "green naphtha" 0.763 gr., and "green oil," 0.758 gr. Naphtha treated with chemicals, distilled, and is ready for market. Green oil treated and distilled fractionally into light oils and heavy oils, which latter contain solid paraffins. Light oils must be distilled and treated twice before being given finishing treatment. After paraffin is removed from the heavy oil it is called blue oil, which must be treated and distilled before ready for last treatment as lubricating oil. Acid stirred in oil for an hour and, after standing, the acids combined with basic impurities settle to the bottom as black tar, and are run off. At each intermediate treatment use as much acid as possible without attacking the olefines. For green oil, vitriol tar of final treatment may be used to some extent (3% by volume). In finishing treatments use enough acid to make white bubbly tar; this is to produce right color in finished product. Oil must be well refined before receiving final treatment. For finishing treatment, weak caustic soda solution used. Oils are put in shallow tanks, after washing, and exposed to light for 24 hours to brighten. If oil is very slowly brought to the neutral point after acid treatment, it is sure to set to jelly-like mass. Temperature at over 100° F. desirable for treatment with acid. Finishing treatment at 60° F. or below. Vitriol tar washed free from acid with hot water, and burned. Amount of acidity left in burning oil after sulfuric acid treatment is 0.1% of SO_3. Products belong to two series, paraffin and olefines. Impurities left from refining little investigated. Yield of paraffin 12%.

Paraffin: Solid paraffin separated in two stages (1) heavy oil plus paraffin, obtained in second distillation, cooled and pressed. (2) Expressed oil after distillation again cooled and pressed, cooling down first, by atmosphere, then by freezing machine. Slow cooling gives more paraffin and better lubricating oil. Solid paraffin liquefied has gravity of an oil which at 60° is 0.810 sp. gr. Heavy oil of 0.863 setting at 42° F. loses 10% paraffin, has sp. gr. 0.872, setting point 20° F. Three processes used to refine paraffin. (1) treatment with chemicals; (2) sweating; (3) treating with naphtha. Slight treatment with oil of vitriol at 140° F. or under. Soda compounds must be washed out. Scale is sweated by melting and running it to cool in shallow pans. Cakes put into chambers where low melting point paraffin melts and flows along with oil leaving only hard paraffin crystals. Best refined paraffin made by washing with naphtha. Scale melted and 25-30% of shale naphtha mixed with it and then is allowed to solidify. Next it is pressed and naphtha runs out taking coloring matter with it. Two such treatments are required. Steam blown through melted paraffin to rid it completely of naphtha. Paraffin then treated with char from prussiate works, settled, and filtered through cloth and paper. All oils should have high flash point, naphtha included. Lamp oils should distill under 300° F. and flash should be over 160° F. Marine sperm oil, sp. gr. 0.830; flash point, 230° F. Lubricating oil, flash point 320°-400° F. according to gravity. Total refining losses under 30%. Total fuel required for 1 ton shale, 1 cwt. of coal, including breaking shale, raising steam, haulage, pumping, etc.

91—VALENTINE, G. A Carbonaceous Mineral or Oil Shale from Brazil. South Wales Inst. Eng. Proc., *17*, 20-28 (1890).

Describes oil shale from Bahia, Brazil, and theorizes as to its origin.

92—BEILBY, G. T. The Nitrogen of Crude Petroleum and Paraffin Oils. J. Soc. Chem. Ind., *10*, 120 (1891).

Crude distillate from Scottish oil shale contains ⅛ to ¼ the N_2 of the original shale. 1.16%-1.45% N_2 is in form of basic tars which are removed with sulfuric acid (sp. gr. 1.220). Crude shale oil redistilled leaves residue of pitchy coke which contains 3% of N_2. In the removed basic tars, neutralized and distilled, N_2 % in various fractions is constant—about 3.24% and undistilled residue contains 4%.

American Petroleum: In distillation 10% of crude oil remains as residuum. SO_2 separates out a pitchy tar, free from odor of pyridine bases characteristic of shale tar. Nitrogen determinations made by soda lime in extra long tubes heated very slowly to give plenty of time for decomposition of basic tar vapors by red-hot soda lime. If any sensible quantities of oily or tarry matter appeared in condensation bulb experiment was rejected as likely to give too low a result. Quantity of NH_3 very small. It was absorbed in hydrochloric acid and weighed as platinum double chloride. Analysis made of residuum of pitchy coke left on distillation and of tar separated from distillate by sulfuric acid gave:

	% Nitrogen
Residuum	0.080
Coke (1/10 of residuum)	0.375
Tar (1/17 of residuum)	0.710
Amount of nitrogen in the original oil equals	0.008
Scottish ozokerite	.296
" natural petroleum	.296
" distilled petroleum	1.160

Percentage of N_2 depends on the nature of organic remains from which it was derived. Animal remains, seeds, and highly nitrogenous parts of plants are higher in nitrogen than coals formed from woody parts of trees.

	% Nitrogen
Scottish shale oil from retorts	1.160
" ozokerite	.296
American petroleum residuum	.080
Baku petroleum residuum	.050
" "	.050
Galician ozokerite	.188
Scottish basic tar	3.900
American residuum tar	.710
Scottish crude still coke	3.200
American " " "	.375

93—REDWOOD, BOVERTON, and TOPLEY, WM. Report on the Riacho Doce and Camaragibe shale deposits on the coast of Brazil near Maceio. London, 1891.

94—ROWAN, F. J. On the Physical Conditions Existing in Shale Distilling Retorts. J. Soc. Chem. Ind., *10*, 436-443 (1891).
Discussion of different temperatures in different shale retorts and their effect on the products.
As long as carbon remained residue was infusible carbon, but when it was gone mass fused.

95—STONE, G. H. Notes on Asphaltum of Utah and Colorado. Am. J. Sci., 3rd ser., *42*, 148-159 (1891).
Describes oil shales of Colorado and Utah and discusses their possible relation to origin of asphalt veins.

96—BERTRAND, C-Eg., and RENAULT, B. Pila Bibractensis et le Boghead d'Autun. Bull. Soc. d'Histoire naturelle d'Autun, *5*, 159-253 (1892).
An extensive discussion of the Pila (Pline) of the Autun Boghead.

97—CHESNEAU, G., Paris. Rapport sur l'Industrie des Huiles de Schiste en France et en Angleterre (1892).

98—MILLS, EDMUND J. Destructive Distillation. 4th ed., Gurney & Hackson, London (1892).

99—CHESNEAU, G. L'Industrie des Huiles de Schiste en France et en Ecosse. Ann. des Mines, 9th ser., *3*, 617-673 (1893).
Report on shale oil recovery in Scotland and France. First researches made on French shales by Laurent de Ruchenbach in 1830. Industry antedates that in Scotland. Retorts used in France are of the non-continuous type, holding from 13 to 16 hectoliters. Retorts grouped in batteries of from 12 to 24. Are rectangular in cross section and have three orifices, one for charging, one for products of distillation, and one for discharge of spent shales. Each retort has own chimney and vapor lines from which products may be handled separately. Shales come from the retorts with from 9 to 10% carbon and are used as fuel. Charge dropped from retort into firebox, where it is allowed to burn, after which it is carted away. Run takes about 24 hours. Furnace heated before charging and the distillation starts immediately upon charging. First NH_3 vapors come off for 3 to 4 hours and then the oil for 8 hours. Furnace is cooled for 4 hours. Yield of oil from Autun shales is 5.25 liters per hectoliter of shale. From Buxieres one cubic meter of shale gives:

Oil, 0.890-0.902 sp. gr.... 45-58 liters
Ammonia water ..... 50-60 liters
Gas ..... 24 cubic meters

Describes method of refining the oil. Laboratory methods have shown that dry distillation gave 42 liters of oil, sp. gr. 0.955, whereas with steam the yield was 82 liters of oil, sp. gr. 0.973 per ton. Indicates possibility of substituting Scottish for French practice.

101—MOORE, R. T. The Mineral Oil Industry of Scotland. Fed. Inst. Mining, End., Trans., *4*, 36-47 (1893).
Describes briefly geology and method of mining oil shale, also refining of shale oil and different value of shale beds. Boghead or Torbanhill mineral near Bathgate yielded 100-120 gals. oil per ton, but is practically exhausted. Scottish shales of the present belong to calciferous sandstone period. Thickness of shale bearing strata 3000 ft. Following seams of shale have been recognized: Dam, Mungle, Grey, Fill, Broxburn, Dunnet, Barracks, and Pumpherston. Seams vary much in thickness and quality at different locations. Seams down to Broxburn are richer in oil; those below are richer in ammonium sulfate. So far none of seams under the carboniferous limestone have been worked. Young and Beilby retort 28 ft. high, heated by gas and coal fires, heat being carried around outside of retort by flues. At intervals of 6 hours, 800 cwt. of shale are put into retort. Retort holds 30 cwt. Twenty-four hours required for shale to pass from top to bottom of retort. At lower portion of the retort NH_3 is given off; two feet from bottom of retort steam is passed in at pressure of 1 pound. 1-3 cwt. of coal used per ton of shale. 50 to 120 gals. of water for steam per ton shale. All gases drawn by exhaust to condenser. Oil is led to refinery and water treated for ammonia. Incondensable gases are passed through scrubbers.

Result of treating 100 gals. of crude:

Burning oil.....	36	gallons
Lubricating oil.....	10	"
Medium oil.....	13	"
Paraffin scale.....	12	"

102—CADELL, H. M. The Oil Shales of the Scottish Carboniferous System. J. Geol., *2,* 243-249 (1894).
Describes geology of these shales.

103—CARNE, J. E. On Certain Shale and Coal Lands in the Capertee Valley District, New South Wales. New South Wales Geol. Sur. Record, *4,* 39-48 (1894).
Describes geology of kerosene shale and coal bitumens in the Capertee Valley district.

104—IRVINE, R. Shale Oil Industry. J. Soc. Chem. Ind., *13,* 1039-1044 (1894).
Summary of the advances of typical industry since 1889. 72 lbs. $(NH_4)_2SO_4$ from 1 ton of shale pays all expense of manufacture, thus crude oil costs nothing. Henderson process (distillation begins at 900° F., shale char exposed, in presence of superheated steam, to 1300° F.) used. Vertical retort 28 ft. high, contents kept in motion by rollers at bottom of retort, which action increases yield of $(NH_4)_2SO_4$ and permanent gases. Yield with this process per ton Broxburn shale: 31 gals. oil; 1500 cu. ft. gas; 44 lbs. $(NH_4)_2SO_4$. With Drumshorland shale at Broxburn's Company's Roman Camp Works: oil, 20 gals.; $(NH_4)_2SO_4$, 72 lbs. Spent shale contains 26% alumina. Crude solid paraffin from filter presses melted and pumped directly into horizontal trays for sweating. Before filling trays diaphragms are covered with water to prevent paraffin from running through; after paraffin is set water is run off. Heat then applied and various products are run off, through suitable pipes, to receiving vessels. Diaphragm is of wire gauze and fixed to ends of tray with bolts. Bottoms of trays communicate with short pipes with swivel nozzles, constructed to work with worm wheels on vertical shaft; thus all swivel nozzles from bottoms of trays may be turned at the same time.

105—HAASLER, F. Z. Angew. Chem., *9,* 288, 318 (1896).
A contribution to the action of aluminum chloride on various oils and compounds. States that cyclic unsaturates in coal tar are polymerized by much smaller quantities of aluminum chloride than unsaturates in lignite and shale tars.

106—BEILBY, G. T. Thirty Years' Development in the Shale Oil Industry. J. Soc. Chem. Ind., *16,* 876-886 (1897).
West and Mid-Lothian shale occur below coal measures in this order: Fells, Broxburn, Dunnet, Barracks and Pumpherston seams. Seams have been worked in same order.

Yields: Fells seam, 35 gals.; Broxburn seams, 32 gals.; Dunnet seams, 25 gals.; Pumpherston seams, 20 gals. Lower seams yield greater percentage of paraffin wax and NH_3 than upper seams; therefore, yield of oil does not represent value of shale. Pumpherston and Dunnet seams most important in 1897.

Both vertical and horizontal retorts used, first type giving oil richest in paraffin wax (at Oakbank). In 1863 Wm. Young devised retort which could be kept at low red heat. Fault: Carbon formed between walls of double casing, thus obstructing passage of heat to shale, thereby adding greatly to amount of fuel used for distillation. In 1872 retort was developed which utilized residual carbon in spent shale as fuel for carrying on distillation but this retort could not be successfully operated by unskilled labor. Later Henderson perfected retort involving this principle. Vertical retorts were improved so that better oil was obtained and less fuel used. Some companies used Henderson's and some vertical type which is cheaper to operate than former. Vertical retorts give small yield of NH_3. Young and Beilby, at about same time, developed retorts upper part of which could be kept at low red heat for distilling off paraffin oil while lower part containing spent shale was kept at much higher temperature and spent shale treated with steam in order to convert the residual N_2 into NH_3. Young and Beilby also tried mixing air with steam for purpose of burning part of fixed carbon, thus supplying heat necessary to enable remainder of carbon to decom-

pose part of steam to set free, as NH_3, the fixed N_2.

Refining of Crude Oil: Oil of vitriol used to remove basic tars and resinous bodies; caustic soda solution for creosote, tars, and sulfur compounds. Different oils separated by fractional distillation, and paraffin by cooling, crystallization and filtration. Color of lubricating oils was improved by distilling heavy oils off caustic soda; viscosity raised by liberal use of superheated steam in distillation; setting point lowered by improved freezing, washing and filtering. Henderson's apparatus for continuous distillation of oils reduced refining loss 3½%; also reduced cost of chemicals. Sweating process for paraffin has superseded old naphtha process, cheaper and safer.

107—GOODCHILD, J. G. Some of the Modes of Origin of Oil Shales, with Remarks on the Geological History of Some Other Hydrocarbon Compounds. Edinburgh Geol. Soc. Trans. *7*, 121-131 (1897).

While some hydrocarbons are result of inorganic action, others, especially oil-bearing shales, were formed by water carrying organic matter down and depositing it in lakes from which water evaporated. Animal and plant tissue converted into mucilaginous matter by sulfates.

108—HENDERSON, N. M., CRICHTON, H. A., and BRYSON, J. The History of Shale Retorts at Broxburn. J. Soc. Chem. Ind., *16*, 984-993 (1897).

Historical development of retorts described by N. M. Henderson. Philipston retort discussed by H. A. Crichton. Pumpherston retort discussed by James Bryson.

Bryson Retort: Top of cast iron 11 ft. by 2 ft. at top and 2½ ft. at bottom. Bottom of fire brick 20 ft. long, 3 ft. wide at bottom. Heat applied around the brick part.

Henderson Retort: Height from ground level to top of hopper, 63 ft. Metal part of retort 14 ft. long and 2 ft. 9 in. by 1 ft. 3 in. at the top. Brick part 20 ft. long and 4 ft. 8 in. by 1 ft. 10 in. at the bottom.

109—HEUSLER, F. Ueber die Zusammensetzung der Schottischen Schiffertheeröle, ein Beitrag zur Theorie der Theerbildung. Ber. *30*, 2743-52 (1897).

Distilled Scottish oil and determined the composition of fractions. Following is comparison of same fraction from brown coal and Scottish shale on fractions below 110°:

	Scotch Oil	Brown Coal
Paraffin	42%	16%
Naphthenes	10	4
Aromatics	7.3	45
Ethylenes	39	31

Aromatics determined as dinitrotoluene. Total unsaturated determined by heating for one hour with 7.5% of aluminum chloride and distilling with steam. Small amount of aromatics in shale oil might have been due to pyrogenic actions of paraffins but the large amount in brown coal must have been ready formed. Sample boiling below 180° also examined. Contained 44-45% paraffin, and specific gravity tests showed that it contained 20% naphthenes. Sulfur also detected.

111—MIRON, F. Les Huiles Minerales Petrol Schista Lignite. Paris (1897).

Book dealing with oils in general, with chapter devoted to shales, describing French retorts and methods of recovering products; also describes Scottish practice. Material taken largely from Chesneau.

112—BERTRAND, C. E. Caracteristiques des Schistes Bitumineux du Bois d'Asson (Basses Alpes). Compt. Rend., *126*, 1677-1679 (1898).

113—HENRIQUES, R. The Scottish Shale Oil Industry. Chem. Rev. Fett-Harz Ind., *5*, 61-4, 81-6, 108-12, 125-9 (1898).

114—REDWOOD, I. I. A Practical Treatise on Mineral Oils and their By-Products. (1898.)

Includes short history of Scottish shale-oil industry, geological and geographic distribution of Scottish shales, recovery of acid and soda used in oil refining, and list of patents relating to mineral oils.

115—CADELL, H. M., and FLETT, J. S. On an Ash Neck in the Broxburn Shale Works at Philpstoun. Edinburgh Geol. Soc. Trans., *7*, 477-480 (1899).

In workings of the Philpstoun Oil Co. in Broxburn shale about two hundred feet below the surface, volcanic neck was discovered. It was oval in shape and some seven hundred feet in diameter in longest direction. Seems to be submarine volcano, as evidenced by rounded quartz pebbles and sand grains. Shale is not burned up near the neck but remains good in quality up to edge. Discussion of petrographical character of material from the neck appended by John S. Flett.

116—HENDERSON, N. M. History of Shale Retorts at Broxburn. (Pumpherston Patent Retort by Bryson.) J. Soc. Chem. Ind., *18,* 246-248 (1899).
Gives history of retorts and composition of products made by each type of retort.

117—OLLIPHANT, F. H. Mineral Resources of the U. S., 242-4 (1899).
Description of Scottish oil shale industry.

118—STEUART, D. R. Refining Shale Oil. J. Soc. Chem. Ind., *18,* 248-249 (1899).
New retort, as developed at that time, gave more oil but oil was more difficult to refine. Solid paraffin yield increased. More sulfur in products from new retort. Henderson continuous still yet used. Acid used twice in refining and then used in NH_3 recovery. Fixed N_2 caused by sucking in air. N_2 equivalent to 4 lbs. $(NH_4)_2SO_4$ per ton found in some retorts. Others less than 2 lbs. Amount of vitriol used 3.39% of amount of crude oil, and 7.21% by weight. Caustic soda, 0.84% by weight of 70% soda. Cost of refining gallon of oil, 0.73 d.

119—BRANNER, J. C. Oil Bearing Shales of the Coast of Brazil. Am. Inst. Min. Eng. Trans., *30,* 537-554 (1900).
Shales along the coast of Brazil are tertiary. Map of area given. Camaragibe shales yield from 7.8 to 30.55% volatile. Combustible non-volatile, 3 to 12%. Ash, 60 to 90%. Riacho Doce shales about the same.

121—DUNLOP, ROBERT. The New Zealand Coal and Oil Company's Work at Orepuki. New Zealand Mines Record, *4,* 219-220 (1900).
Discussion of Scottish type plant being erected at Orepuki. Output of oil 2000 gals. per day.

122—DUNLOP, R. Oil Shales at Orepuki. New Zealand Dept. Mines Rept., *C3,* 52-54 (1900).
Describes plant being installed to get oil and ammonia from oil shales at Orepuki, New Zealand.

123—STEUART, B. Contribution to the Composition of Shale Naphtha. J. Soc. Chem. Ind., *19,* 986-89 (1900).
Experiments to determine what saturated hydrocarbons were found in shale spirit. Four gallons of 0.737 naphtha treated three times with 10% concentrated sulfuric acid and washed with water and alkali. Oil dried over solid caustic and distilled in iron still with head. One gallon obtained. This was fractionated eight times. Olefines further removed from fractions with sulfuric acid and caustic. Benzene and toluene removed by sulfuric acid and nitric acid. Identified number of paraffins and found considerable benzene and toluene.

124—ANON. New Zealand Coal Oil Co. New Zealand Mines Record, *4,* 470-471 (1901).
Relates to operation of retort and process of New Zealand Coal and Oil Company's work at Orepuki.

125—CADELL, H. M. Geology of Oil Shale Fields of the Lothians. Edinburgh Geol. Soc. Trans., *8,* 116-162 (1901).
Good description, with map. Extent of fields, products, illustrations, and sections.

126—CADELL, H. M. Geology of the Oil Shale Fields of the Lothians. Edinburgh Geol. Soc. Trans., *8,* 116-162 (1901).
Good description with maps of oil-bearing formations of lower carboniferous systems.

127—CADELL, H. M. Oil Shale Fields of the Lothians. Inst. Mining Eng. (London) Trans., *22,* 314-371 (1902)
Good description with map and short discussion of oil shale industry.

128—ELLS, R. W. Bituminous Shales in Nova Scotia and New Brunswick, with Notes on the Oil Shales in Scotland. Summary Report. Geol. Sur. Can., *15,* 363-9 (1902).

Report on geology of oil shales in both Canada and Scotland. Extract from Dr. Hows' paper (Stillman's Journal and Edinburgh Phil. Jour., 1860) gives following comparison between coal, stellarite, and shale.

	Coal	Stellarite	Shale
Volatile	33.58%	66.56%	30.65%
Fixed Carbon	62.09	25.23	10.88
Ash	4.33	8.21	58.47

and following ratio of carbon to hydrogen:

Cannel coal, Wegan	100- 5.65
Cannel coal, Leshmahagow	100- 8.71
Capeldrea Cannel coal	100-10.05
Torbanite, Scotland	100-12.43
Albertite, New Brunswick	100-10.85
Stellarite, Pictou, Nova Scotia	100-12.43

Following are oil yields per ton from Fraser Oil Works:

Union Oil coal, W. Va	32 gals.
Elk River coal, W. Va	54 "
Kanawha coal, W. Va	88 "
Leshmahagow Cannel, Scotland	40 "
Albertite, N. B	92-100 "
Torbanite, Scotland	160-125 "
Stellarite, or Stellar coal	50 "
" " " " #2	50- 74 "
" " " " #1	123-126 "

From standpoint of oil and by-products Canadian shales are better than those of Scotland.

129—GARRETT, T. C., and SMYTHE, J. A. The Bases Contained in Scottish Shale Oil. J. Chem. Soc., *81*, 449-56 (1902). Pt. I.

Analyzed oil obtained by treating green naphtha with sulfuric acid (dil. 1:9) fractionally distilled-isolated fractions:

Below 120°	0.3%
120-160°	13.4
160-200	43.2
Above 200°	43.1

Portions boiling below 164° treated with $HgCl_2$ (solution of bases in HCl being added to hot 10% solution of $HgCl_2$). Mercury salts fractionally crystallized from water slightly acid with HCl. Bases regenerated by removing Hg either by NaOH or H_2S.

	Boiling Point
Pyridine	115-116° C.
2 Methyl pyridine (Picolin)	129.5°
2-6 Dimethyl pyridine	142.5°
2-4 Dimethyl pyridine	159°
2-5 Dimethyl pyridine	155°
2-4-6 Trimethyl pyridine	170.5°

Constitution proved in each case by oxidation to corresponding acid (with $KMnO_4$).

130—CONDER, N. Oil Shales in Tasmania. Australian Mining Standard, *21* (1902).

131—GEIKE, A. Two papers on the Geology of Fyfe. Mem. Geol. Survey Scotland, *10*, 284 (1900), and *16*, 421 (1902).

132—GRAY, THOMAS. Phenols from Oil Shale. J. Soc. Chem. Ind., *21*, 845-47 (1902).

Residue from 3200 gals. green naphtha treated with 28 gals. of NaOH (27% NaOH) fractionated and separated the phenols. No p-cresols; some guanole; 5-6% phenol; 12-13% o-cresol; 1.30-35% m-cresol; and xylenols.

133—BLAKE, G. S. Oil Shale from Natal (analysis). Imp. Inst. Bull., *1*, 74-76 (1903).

Thin shale between coal beds yields less than 1 gal. of oil per ton.

134—CARNE, J. E. The Kerosene Shale Deposits of New South Wales. New South Wales Geol. Survey Memoir, No. 3 (1903).

Memoir of 333 pages devoted to kerosene shales of New South Wales. Part I deals with shales in general, giving physical and chemical properties and origin. Part II takes up distribution, mode of occurrence, and properties of shales of New South Wales. Part III, specific deposits of New South Wales. Part IV, statistics. Part V, analogous substances including French shales and Scottish shales, etc. Appendix includes petrological notes of Capertee Valley district and discussion of mining titles for coals and kerosene shales.

135—GARRETT, T. C., and SMYTHE, J. A. The Bases Contained in Scottish Shale Oil. J. Chem. Soc., *83*, 763 (1903). Pt. II.

Examination of fractions boiling about 164° resulted in isolation of only two

pure substances, 2-4-6 trimethyl pyridine most abundant. 2-3 dimethyl pyridine, b. pt. 163-164, 768 mm. was found.

136—LÜDY, F. Ichthyol. Chem. Ztg., *27*, 984 (1903).
Ichthyol is water soluble oil obtained by distillation of bituminous shales from Seefeld, Tyrol, and subsequent sulfonation and neutralization of shale oil with NH_3. It comes on market under name ammonium sulfo-ichthyolicum, etc., and up to 1900 was exclusively prepared by Hamburg firm of Gordes, Hermann and Co. Substitutes such as "ichthyoform" have since appeared.

137—SNEDDON, J. B. Description of the Duddingston Shale Mines and the Niddric Castle Crude Oil Works. Inst. Min. Eng., *26*, 122-133 (1903).
Lengthy description of power plant installation, electrical haulage, equipment, and crude oil works at Duddingston shale mines.

138—PLUMMER, JOHN. Shales in Australia. Eng. and Min. J., *78*, 66-67 (1904).
New South Wales deposits found along shallow western edges of coal-bearing areas. Deposits worked at present at Hartley Vale, New Hartley, Genowlan, in Blue Mountain district, and at Joadja in Mittagong district. At Joadja cost of mining was 3s and 9d to 20s per ton. First retort used at Hartley Vale by Hartley Kerosene Co. was circular in form fitted with trays on which shale was placed. Furnace of muffle type. In 1868 Western Kerosene Co., Ltd., began treating shales in ordinary gas retort but finally changed to vertical type. One company had 40 retorts erected at Torbane. They were 46 ft. 6 in. high with cross section of 4 ft. 6 in. by 2 ft. 6 in., holding 14 tons. Tall retorts increased ammonia yield. Crude oil 0.860 sp. gr. is hauled two miles in a tank car and distilled. Products: Naphtha, 3%; gas oil, 65%; blue oil, 10%; paraffin, 8%; tar, 14%.

141—PETRIE, J. M. The Mineral Oil from the Torbanite of New South Wales. J. Soc. Chem. Ind., *24*, 996-1002 (1905).
Describes torbanite and oils obtained by its distillation. Torbanite exists in only three countries, Scotland, Autun, and New South Wales. All occurs in carboniferous or premo-carboniferous epoch. Factors in its make-up are: humic compounds, precipitated by solutions of certain inorganic salts in water; gelatinous bodies of microscopic algae and their secreted oils, spores and pollen grains, and dark brown bituminous matter. No shells, fish bones or diatoms have ever been found. Gelatinous bodies compose 90% of the organic matter present; hence ratio of volatile to fixed carbon is high. Algae cells occur in cannels, but are no longer predominating material. Present Scottish shales have humic matter only, with various amounts of secondary bituminous filtrations. Composition of New South Wales torbanite given by Dixon as follows: carbon, 75.32%; hydrogen, 12.05%; oxygen, 5.49%; nitrogen, 0.28%; sulfur, 0.31%; ash, 6.55%. Soluble in ether, 0.3%; extract consists of saturated hydrocarbons of high boiling point. Torbanite used in New South Wales for gas making, inferior grades being distilled for oil, wax, and ammonia. Composition of Hartley seam as follows: top, 14 gals. per ton; intermediate, 60 gals.; best export shale, 150 gals.; intermediate quality, 60 gals.; bottom, 14 gals. Analysis: naphtha, 3%; solar oil, 60%; heavy oil, 17%; residue, 20%. Crude oil is mixture of paraffins and olefines. Olefines form 60-70% of light distillate, decrease as boiling rises and disappear at 250-400° C. Naphtha (9% of crude) contains about equal proportions of olefines and paraffins. Noticeable amounts of phenols. Small amount of thiophenes. Small amount of naphthenes.

142—ARON, A. L'Industrie Française des Schistes Bitumineux. Ann. des Mines Mémoires, 10th ser., *9*, 47-75 (1906).
Part I discusses modified Scottish retort used in France. It is a Young-Fry model, internally heated by combustion of residues. Operation described. Part II gives results of new retort. Following table shows progress of industry:

Year	Tons Shale Extracted	Hectolitres Oil Produced
1893	186,040	97,820
1895	216,079	108,958
1897	190,302	114,763
1899	209,125	131,865
1901	208,070	131,672
1903	198,280	136,136

In 1893, 820 men were employed in industry and in 1904, 834. New retort effected very considerable change and it is suggested that it be universally accepted. Part III is discussion of market conditions, including discussion of competition with well petroleum. Considering cost and quality of shale oil and well petroleum, shale oil is at great disadvantage.

143—CADELL, H. M., and WILSON, GRANT. Geology of the Oil Shale Fields. The Oil Shales of the Lothians, Pt. I. Scotland Geol. Survey Memoirs, 1-97 (1906).

Memoir is dissertation on oil shales of the Lothians and is divided into three parts. Part I, Geology of the Oil Shale Fields, by Cadell and Wilson. Part II, Methods of Working the Oil Shales, by W. Caldwell. Part III, Chemistry of the Oil Shales, by D. R. Steuart. Part I includes geological position of shale measures, distribution of oil shales, character of shales, and detailed description of each particular section.

144—CALDWELL, W. Methods of Working Oil Shales. Oil Shales of the Lothians, Pt. II. Scotland Geol. Survey Memoirs, 98-131 (1906).

This is Part II and deals with methods of driving the mines, methods of working, timbering, ventilation, and haulage.

145—STEUART, D. R. Chemistry of the Oil Shales. Oil Shales of the Lothians, Pt. III. Scotland Geol. Survey Memoirs, 133-186 (1906).

This is Part III and includes statistics, chemical composition of various shales, processes of manufacture, products obtained, and their uses.

146—ELLS, R. W. The Geology and Mineral Resources of New Brunswick. Canada Dept. Mines, Geol. Survey Branch, 107 (1907).

Thick oil bands of Albert Shales are found in eastern area at Taylorville on the Memramcook River; also near St. Joseph College; at Bellevue; and on east side of Petitcodiac River opposite Hillsborough at Dover. Shales belong to upper part of Devonian system. On upper part of Turtle Creek in western Baltimore, gray shale beds are found with thickness up to 17 to 20 feet. Specific gravity of shale 1.5. Yields large amount of gas of high candlepower, 8500 cu. ft. per ton.

Analysis of Shale from Baltimore

	Per Cent.
Volatile carbon compounds	42.78
Fixed carbon	17.45
Silica	20.88
Alumina	7.91
Iron	1.97
Calcium sulfate	7.56
Magnesia	1.11
Phosphoric acid	.34
Ash	39.70

Other analyses of gray and black shale from Baltimore:

	Gray	Black
Moisture	1.10	0.36
Volatile matter	45.32	39.50
Fixed carbon	1.29	3.00
Ash	50.69	56.10
Sulfur	1.70	1.04

147—HELLSING, GUSTAFF. Shale Oil Industry of Scotland and France. Sveriges Geol. Undersökn Arsb., *2*, 1-92 (1907).

Discusses oil shale industry at length, giving geological as well as economic data.

148—OLIVEIRA, E. P. Sobre Alguns Affloramentos de Carvao no Parana. Escola de Minas de Ouro Preto Annaes, No. 9, 91-94 (1907). Inst. Mining Eng. Trans. (London), *36*, 759 (1907).

On carboniferous oil shale near Conoinhas and Iraty.

149—ANON. The Pumpherston Seafield and Deans Works of the Pumpherston Oil Co., Ltd. Inst. Mining Eng. Trans., London, *36*, 602 (1908).

Description of workings of Pumpherston plant. Employ 1400 men, two-thirds connected with mining department. Distill 1900 tons daily. Refineries handle 20,000,000 gals. per annum. Shale conveyed to breakage machines by wire rope haulage, is then conveyed to hoppers by endless chains. Pumpherston retort: upper part of cast iron 11 ft. long, 2 ft. in diameter at the top, 2 ft. 4 in. at bottom. Lower portion fire brick, about 20 ft. long and enlarges to 3 ft. in diameter. Heat applied externally by burning non-condensible gases. Tempera-

ture near bottom 1200 to 1500° F. Oil gases distilled in the cast iron part at about 900° F. NH_3 distilled in bottom. Vapor and NH_3 waters condensed in aerial condensers. Uncondensed gases pass through NH_3 scrubbers and then naphtha scrubbers, then back to retort to be burned. Steam injected in lower part of retort. Yield about 23 gals. per short ton. Water containing NH_3 passed through tower scrubbers with steam passing in counter current. Steam pressure about 40 lbs. Lime used to remove the last trace of NH_3 from water. NH_3 and steam passes into lead-lined saturators. Sulfate of ammonia precipitated. Refining process described, not essentially different from petroleum refining.

150—ANON. Kerosene Shales. J. Roy. Soc. Arts, *56,* 748; C. A., *2,* 2816 (1908).
Shales found in New South Wales retorted for gas oil, kerosene, lubricating oils and paraffins. Best grades yield 150 gals. per ton.

151—ARNOLD, RALPH and ANDERSON, ROBERT. Metamorphism by Combustion of Hydrocarbons in the Oil Bearing Shales of California. J. of Geol., *15,* 750-9 (1908); C. A., *2,* 522 (1908).
Subterranean fires usually attributed to volcanic action may have been caused by burning shale. Burned shales are found at depth of a thousand feet and it is evident that even in pleistocene times the fires were active.

152—BAKER, O. H. Australian Kerosene Shale. U. S. Cons. Rept. *333,* 107-108 (1908).
Notes preparations to work New South Wales deposits. Deposits 120 miles from Sydney. Cover 41 square miles. Seams from a few inches to six feet thick. Richest is Jaodja mine, 77 miles from Sydney. Yields 130 gals. oil, 15,400 cu. ft. gas per ton. Wolgan: 15-30% ash; yield, 80-160 gals.

153—BRITISH GEOL. SURVEY. The Scottish Oil Shale Industry. Chem. Ztg., *15,* 118; C. A., *2,* 896 (1908).
Review of Scottish shale oil industry, including mining and chemical working of products. Shale yields 17-55 gals. of oil per ton and NH_3 56 lbs. per ton.

154—CALDWELL, WM. Working of Oil Shales at Pumpherston. Inst. Mining Eng. London, *36,* 581 (1908).
Description of workings of the Pumpherston mines. Oil shale contained in eight workable seams. Deepest about 800 ft. Top seams give good yields of oil and NH_3. The lower, or Pumpherston shales, give comparatively large percentage of NH_3 and less oil. Poorer quality as depth increases. Mined by driving down one seam and cross-cutting through others. Gives detailed methods of shooting, etc.

155—CRAMPTON, C. R., and TAIT, D. On Certain New Localities for Oil-Bearing Shales near Edinburgh. Edinburgh Geol. Soc. Trans., *9,* 102-7 (1908).
Geological location, including section of certain shales near Edinburgh in group of rocks called Wardie shales and Granton sandstones.

157—ELLS, R. W. Bituminous Shales in Nova Scotia and New Brunswick, with Notes on the Oil Shales in Scotland. Canada Dept. Mines Summ. Rept., 132-142 (1908).
Describes geology of oil shales of Scotland and of Nova Scotia and New Brunswick and gives results of distillation tests of latter.

158—GREGORIUS, RUDOLF. Mineral Waxes, their Preparation and Uses. Translated by Chas. Salter, London; 71-76 (1908).
Contains section on waxes derived from shale oils.

159—MAGNIN, J. L'Industrie des Schistes Bitumineux. Petroleum, *8,* 20-23, 35-37, 51, 52, 68, 69 (1908).
Describes processes of distillation and refining used in Scotland.

160—WHITE, DAVID. Some Problems in the Formation of Coal. U. S. Geol. Survey Econ. Geol., *3,* 292-318 (1908).
Question of formation of coal not merely of genesis of certain coal but of many coals of different kinds. Important factors, (a) difference in growth and accumulation of organic matter, (b) kinds of organisms contributing to most of accumulation, (c) conditions of organic

decomposition, (d) nature and energy of dynamic force bringing about in varying degrees alteration of organic residues. Need of further observation.

161—STEUART, D. R. Oil Shale Industry of Scotland. Econ. Geol., *3*, 573-598 (1908).

16-35 gals. crude and 30-70 lbs. $(NH_4)_2SO_4$ per ton shale. Refined products of crude are naphtha, 4%; burning oil, 33%; gas oil, 7%; lubricating oil, 20%; solid paraffin, 10-12%.

Middle of shale oil field 13 miles due west of Edinburgh. Field 5-8 miles wide and 16 miles long. Importation of oil from America made necessary greater yield of NH_3 from Scottish shales. Description of shale oil production. Torbanhill or Boghead mineral first used. It is remains of organic matter in original position. Analysis of mineral by Anderson: Carbon, 64.02%; hydrogen, 8.90%; nitrogen, 0.55%; sulfur, 0.50%; oxygen, 5.66%; ash, 30.32%. Geological section of shale oil districts. Good oil shale black or brownish color, fine grained, and free from grit. Very resistant to disintegration by weathering. Tough and sometimes flexible. Under knife thin shavings turn up and curl over. Richer shales nearly always black but range from brown to gray as they decrease in quality. "Plain" and "curly" shales sometimes found in same layer. Carbonaceous matter different from that in coal. Coals yield coal tars but not petroleum distillates. Gravity of distillate from coal over 1. From shale, 0.86-.88.

162—BASKERVILLE, C. Oil Shales in Canada. 7th International Congress of Applied Science. London. Sec. 4a I. Organic Chem., 22-32 (1909).

Use of shale as source of oil in Scotland, Germany, and Australia long known. Gesner claimed to be first to produce it in America. Demonstrated its use in 1846. North American Kerosene Gaslight Co. made it at Newtown Creek, Long Island, and sold it under the name of "Kerosene Oil." In 1853 the U. S. Chemical Manufacturing Co. worked coal tar for lubricating oils at Waltham, Mass. In 1857 the Downer Kerosene Oil Co. first made mineral oil from Albert coal in New Brunswick, Canada. Works were erected by Downer in Boston and Portland, Maine. About this time the New Bedford Co. of New Bedford, Mass., began distilling Boghead coal from Scotland. In 1859 six plants were erected near Pittsburgh, Pa. In 1860 nearly sixty companies were in existence. The following materials were used:

Mineral	Gals. oil per ton
Albert Coal (Albertite)	110
Asphalt Rock (New Brunswick)	64
Pictou Shales (Nova Scotia)	47
Breckenridge Cannel Coals (Ky.)	130
Erie R. R. Coal	47
Newburgh Coal	72
Falling Rock Coal	80
Pittsburgh Coal	49
Kanawka Coal	71
Elk River Coal	60
Cannelton Coal	86
Cashocton Coal	74
Ouachita Brown Coal (Ark.)	68
Ouachita Bitumen (Ark.)	64

Boghead coal imported to the extent of 20,000 tons in 1859. Yielded 120 gals. of oil which gave 65 gals. lamp oil, 7 gals. paraffin oil, 12 lbs. wax. Cost of oil estimated at 63 cents per gal. Analysis of Albertite as follows:

	Wetherill	Gesner
Carbon	86.30%	84.40%
Hydrogen	8.96	9.20
Nitrogen	2.93	3.06
Sulphur	Trace	Trace
Oxygen	1.97	2.22
Ash	0.10	0.12

Price in 1863-74 was $15 to $20 per ton. "Black Band" shales in New Brunswick yielded 63 gals. In Westmoreland Co. 37 gals. A company in Westmoreland Co. had 100 retorts with capacity of 100 bbls. per day. Shale produced 7,500 cu. ft. of gas per ton. Pictou shales also utilized. Describes various shales. Albert shales gave 55 gals. per ton, sp. gr. 0.93.

	Per Cent.	Per Ton
Naphtha (0.72 gr.)	9.09	6.9 gals.
Light oil	16.57	12.0
Heavy oil	14.00	7.8
Paraffin	7.54	35 pounds
Total	47.20	
Loss	52.80	

Forty tons were sent to Pumpherston Oil Co., Ltd., and run through its ex-

perimental plan. Gave 48 U. S. Gals, per long ton; 77 lbs. $(NH_4)_2SO_4$; oil, brownish black, sp. gr. 0.92; flash, 194° F; setting point, 54° F.; sulfur, 0.62; B.T.U. value, 18,474 per lb.; gas analyses as follows:

	Per cent
Carbon dioxide	29.67
Carbon monoxide	5.06
Olefines	1.33
Methane	11.02
Hydrogen	59.92

Calorific value, 305.3 B.T.U.'s per cu. ft. Sp. gr., 0.613 (air = 1). Oil yielded as follows:

	U. S. Gal. per Ton
Naphtha	0.7
Burning oil	5.1
Gas oil	6.7
Cleaning oil	0.9
Lubricating oil	4.9
Paraffin wax	1.3
Total	19.6
Residuum	1.8
Creosote, tar, pitch, etc.	26.6

Large deposits available that will yield one barrel of oil and by-products per ton.

164—BASKERVILLE, C. Economic Possibilities of American Oil Shales. Eng. and Mining J., *88*, 149-154, 195-199 (1909).

Gives history of oil shale industry (especially American); discusses methods of mining and treatment in light of Scottish practice. Pages 149-154 give historical development. Pages 195-199 include tests made on New Brunswick Baltimore shale both in experimental and commercial apparatus.

Commercial Tests. Gave 40 imp. gal. or 48 U. S. gal. per ton and an average of 47 lbs. $(NH_4)_2SO_4$. Gives results on refined product. Describes methods of determining (NH_3) (Bailey method). Calorific value discussed.

Run on 36 tons of New Brunswick shale in Pumpherston experimental Bryson retort yielded average of 40.09 Imp. gals. of crude and 76.94 lbs. $(NH_4)_2SO_4$ per ton. Gas: CO_2, 29.67; CO, 5.06; olefines, 1.33; methane, 11.02; H_2, 52.92; calorific value, 305.1 B.T.U.; sp. gr., 0.613. Products distilled using 30% steam were:

		Per Cent. of Crude
Heavy naphtha.....	0.767 gr.	1.62
Burning oil.....	0.7954 gr.	10.04*
Gas oil.....	0.8314 gr.	14.78
Cleaning oil.....	0.8713 gr.	2.83
Lubricating oil.....	0.8957 gr.	9.58
Crude wax.....	....	3.19

(*Required 4 gals. H_2SO_4 (1.84 gr.) to refine 100 gals. shale oil.)

Additional information: Analysis of shale: moisture, 0.35%; volatiles, 44.77% fixed carbon, 5.95%; ash (phosphoric acid, 0.3%, trace of chromium, light brown color), 48.93%; total, 100%. Sulfur, 1.43%; sulfur in coke, 0.2%; nitrogen, 1.96%.

165—BASKERVILLE, CHARLES, and HAMOR, W. A. Oil Shales of America. J. Ind. End. Chem., *1*, 507-11 (1909). C. A. *4*, 1234. (Taken from paper read before the N. Y. Sec. of Soc. Chem. Ind., April 23, 1906.)

Shale oil known in England and Germany, New Zealand and Australia, and America. Gesner operated plant using coal in 1855. Review of coal-oil industry from 1846 to 1860, when discovery of petroleum stopped the industry.

166—BELL, J. M., and CLARKE, E. Whangaroa Division. Bull. 8, New Zealand Geol. Sur., p. 96 (1909).

167—ELLS, R. W. Joint Report on the Bituminous Oil Shales of New Brunswick and Nova Scotia, also on the Oil Shale Industry of Scotland. Canada Dept. Mines (1909).

60% of the total N_2 is recovered in the Pumpherston plant. Sp. gr. of crude is 0.86 to 0.96 with congealing point of 32° C. Crude contains about 1% N_2. Most of distillation occurs below 427° C. 554° C. is maximum temperature required in retort. A detailed account of each step in manufacture of shale oil is given. Geological position and character of oil shale deposits of Canada. Union oil-coal of W. Va. yields 32 gals. crude oil per ton. French shale at Autun and Buxieres resembles boghead coal. Yields 30 gals. crude which fractionated gives burning oil and spirit 25 gals.; lubricating oil, 10 gals.; paraffin, 2½ gals. Servia shale yields 43.5 to 45.5

gals. per ton. 100 gals. of crude shale oil gives: burning oil, 30 gals. sp. gr. 0.810-0.820); intermediate oil, 4.5 gals. (0.840-0.865); lubricating oils 15.5 gals. (0.880-0.885); paraffin, hard and soft scale, 14.3 gals. Shale from Wolgan and Capertee valleys yields 17,560 cu. ft. gas per ton, having candle-power of 48.52. 101 gals. crude of sp. gr. 0.877 gave on fractionation:

Naphtha	8.48%
Gas oil	15.87
Illuminating oil	19.50
Lubricating oil	22.80
Scale paraffin	6.42
Vitriol, tar, etc.	24.65
Residue	3.28

Very full report on Canadian shales. Exceedingly rich shale found on Melville Island in 1909, inside Arctic Circle.

168—ELLS, R. W. Oil Shales of Eastern Canada. Canada Dept. of Mines Summ. Rept., 200-216 (1909).

Describes occurrence and gives large number of tests of oil shales in Eastern Canada.

Shales of New Brunswick: Albert shale in Albert and Westmoreland Cos. Also same formation in Kings Co. Albert mines 20 miles south of Moncton. Shales extend eastward past Hillsborough and across Petitcodiac River to Memramcook River and near Dover. Extend westward from Albert mines through Baltimore, Turtle Creek, Prosser Brook, Pleasant Vale, Mapleton, Elgin and Goshen. Albert mines and Baltimore shales richest of New Brunswick shales all of which belong to the Perry formation. Dover shales yield per ton 27.2 Imp. gals. of 0.921 sp. gr., 29.5 lbs. $(NH_4)_2SO_4$. Taylorville shales 37-48 gallons crude of 0.900-0.925 sp. gr., 93-110 lbs. $(NH_4)_2SO_4$. Baltimore shales, 40-56 gals. crude of 0.981-0.895 sp. gr., 30-110 lbs. $(NH_4)_2SO_4$. Prosser Brook shale, 30 gals. crude, 0.895 sp. gr., 75 lbs. $(NH_4)_2SO_4$. Pleasant Vale, Mapleton and Elgin shales poor yields. Goshen shale, 27.5 crude, 0.897 sp. gr., 36 lbs. $(NH_4)_2SO_4$.

Oil shales of Nova Scotia: Huataport, Horton, Cheverie, Walton along Avon River. Here shales are abundant but are carbonaceous rather than bituminous. Shales of Pictou Co., 44 gals. crude of 0.875 sp. gr. Antigonish Co. shales both plain and curly, 10-23 gals. crude of 0.890-0.917 sp. gr., 17-38 lbs. $(NH_4)_2SO_4$.

Oil shales of Gaspé: 30-36 gals. crude of 0.953-0.977 sp. gr., 40-49 lbs. $(NH_4)_2SO_4$ per ton. Oil in the Gasp shaley sandstone often occurs in form of hardened bitumens.

169—ELLS, R. W. Notes on the Geology of the Oil Shales of Scotland and their relations to somewhat similar Oil Shales in Eastern Canada. Roy. Soc. Canada Trans., 3rd ser., *3*, Sec. 4, 35-44 (1909).

Short sketch of geology of oil shales of Eastern Canada.

171—MARINOZUCO, F., and TONOLLI, J. Ichthyol from Italian Schists. Gazz. Chim. Ital., *39*, II, 575-9 (1909).

172—WEED, R. Oil Shales in Scotland. Iron and Coal Trade Rev., *79*, 205-6 (1909).

Shale composed of numerous small round amber colored bodies having appearance of flattened gooseberry skins charged with blackened matter, the latter comprising volatile substances. Three seams being worked in Broxburn mines—Broxburn (6 ft.), Burly (16in.), and Grey (6 ft.). Oil refined by repeated distillations; fractionated into different required gravities and treated with oil of vitriol and caustic soda. Black tarry matter which settles in bottom of still after this treatment injected with steam into the furnace in form of readily burning spray, furnishing fuel for the works.

173—CHERCHEFFSKY, N. Compt. Rend., *150*, 1338-41 (1910).

Some data on properties of shale naphthas, including indices of refraction.

174—ELLS, R. W. The Oil Shales from the Maritime Provinces (Canada). Mining Soc. Nova Scotia J., *14*, 1-12 (1910).

Outlines possibilities of oil shales of Canada and describes briefly the results of tests of these shales in shale works of Scotland.

176—ELLS, R. W. Commercial Values of Oil Shales in Eastern Canada, based on their Content by Analysis in Crude Oil and Ammonium Sulphate. Mining Soc. Nova Scotia J., *15*, 26-56 (1910).

Results of laboratory scale tests of vari-

ous shales in Eastern Canada. Commercial value depends on (1) crude oil obtained, (2) ammonium sulfate, (3) cost of mining. Estimates that Canadian shales are in better position than Scottish to yield profitable returns. Scottish plant cost £65 per ton capacity per day. Complete 180 retort Pumpherston plant would cost £80,000.

Mining costs in Scotland	$1.00 per ton
Retorting costs in Scotland	.40 " "
Sulfate mgfr. in Scotland	.46 " "

177—GRAEFE. ED. The Scottish Shale Oil Industry. Petroleum, *6*, 69-79 (1910); C. A., *5*, 374.

History of shale distillation back as far as 1694. Refined products in 1900 were naphtha, burning oil, gas oil, lubricating oil, paraffin, ammonium sulfate, coke. Organic matter of shales not bitumen and not soluble. Gives data on number of plants operated, shale distilled at various intervals of time and price of products. Good Broxburn shale gives 25% liquid and 75% residue. Latter contains 70% ash, mostly SiO_2, Al_2O_3 and Fe_2O_3 with small amount CaO and MgO, 0.5% carbon, 0.5-1% H_2, 25% N_2 goes into tar, 40% into NH_3 water, 29% remains in residue and escapes as gas. Gives cuts and drawings of mines and description of mining methods. Retorts have increased in height. Steam admitted to increase NH_3. Diagram of Young, Bryson and Henderson retort. Gas after passing scrubber to remove NH_3 and naphtha has following composition:

Heavy hydrocarbons	1.2%
Oxygen	1.0
Carbon Monoxide	7.8
Methane	9.2
Hydrogen	38.6
Nitrogen	16.2
Carbon Dioxide and Hydrogen sulfide	26.0
Sp. gr. (air = 1)	0.62

Heat of combustion 2700 cal. per gram

178—GRAFE, E. Ueber Canadischen Oelschiefer. Braunkohle, *9*, 424-6 (1910).

Brief description of Canadian oil shales including analyses of shale and products.

179—JENE, L. H. Oil Shales of the Blue Mountain New South Wales. Eng. and Mining J., *90*, 407-8 (1910); C. A. *4*, 2727 (1910).

Article on sampling shales in mines. Shale sampled by taking out quantities at regular intervals along face. Low specific gravity usually denotes good shale. Specific gravity runs from 1.08 to 1.229. Streak of good shale is almost white, poorer ones darker. Fracture conchoidal in good and semi-conchoidal in poor.

Lustre highly silky in good, dull in poor. Sixty per cent volatile matter in gas shales, lower volatile shales used for retorting. Per cent volatile hydrocarbons times 2 is roughly gallons per ton. (Data, of course, only good for N. S. W. shales.)—

181—PHYÄLÄ, EVALD. Die Nadelförmigen Paraffin-Karstalle und ihre Bedeutung für das Schottlandisches Schwitzerverfahren bei der Paraffinfabrication. International Chim. Appl. Sess., *7*, Section 4, 32-38 (1910). Petroleum, *4*, 1392; C. A., *4*, 248 (1910).

Paraffin exists both as needles and leaflike plates. The longer cooling the greater the proportion of plates and the harder to filter. Equilibrium relation between two forms not worked out.

182—LEVERIN, HAROLD. Description of a Commercial Method and Apparatus for the Analysis of Oil Shale. Canada Dept. Mines Sum., Paper No. 26a, pp. 153-156.

Describes still for determining oil in oil shales. Apparatus essentially the ordinary Scottish method in which tube is heated in gas furnace and products collected in water cooled vessels instead of being condensed by air. NH_3 determined by ordinary Scottish methods.

Henderson retort yields 16 to 20 lbs. NH_3 per ton on shale which had N_2 equivalent to 74 lbs. $(NH_4)_2SO_4$ per ton. Young-Beilby retort gave twice as much and Pumpherston gave 52 lbs. per ton. Ammonia method based on Pumpherston yield. Author states there is no appreciable difference between nitrometer method of determining NH_3 and that in which it is distilled over and titrated (Cochineal indicator).

183—THOMPSON, A. B. Petroleum Mining and Oil Field Development under the Caption Oil Field Development, 118-121 (1910).

Short general discussion of oil shales. Torbanite and kerosene shales of New South Wales partake of nature of coal. Yield 60-75% volatile matter and 6-16% fixed carbon. West and Mid-Lothian shales found in seams 1-8 feet thick in synclinal basins of carboniferous system. Yield 20-40 gallons oil per ton. Good oil shale distinguished by brown streaks, toughness, and resistance to disintegration by weathering. "Plain" shale smooth and flat. "Curly" shale contorted and richer than "plain." Molten igneous rock introduced into shale deposits at one time or another, caused natural distillation and oil thus formed flowed into fissures in the rocks where it has remained.

184—ANON. Oil Shales of Scotland and Their Distillation. Petroleum Rev., *25*, 191-2, 229-30 (1911). C. A. *6*, 535.

Pumpherston works started in 1882; covered one hundred acres. At Pumpherston shale conveyed to breaking machines from mines by endless wire rope haulage; from breaking machines it passes into hopper-shaped hutches, capacity 20 cwt., and is conveyed to top of retorts by endless chain on inclined scaffold. Vertical cylindrical retorts built in sets of four. Upper cast iron part of retort is 11 ft. long and 2 ft. in diameter at top, bottom slightly larger, or 2 ft. 4 in. Lower fire brick part is 2 ft. in diameter at bottom and is 20 ft. long Heated by non-condensible gases mixed with air. Temperature 1200° to 1600° F. in lower part of retort. Steam delivered at slight pressure. Temperature 900° F. in upper part.

Oil and NH_3 gases drawn off together near bottom of cast iron part of retort, and pass through atmospheric condensers from which condensed oil and ammoniacal water flow into separator tanks. Gases next pass through NH_3 scrubbers and then through naphtha scrubbers.

NH_3 water passed through heater and into top of still. Still is 30 ft. high and cylindrical with cast iron trays fixed horizontally every two feet from top to near bottom. Steam is introduced into still at 40 lbs. pressure. Steam and NH_3 gas freed in the still pass through lead-lined saturator and bubbles through holes in lead work placed around circumference at bottom of vessel. Simultaneously sulfuric acid is run into saturator and at certain temperature sulfate of ammonia forms and falls into pit in center of bottom of vessel. Mixture is passed into chambers having perforated bottoms so that the liquor may drain away leaving solid sulfate.

Crude oil allowed to settle 12 to 18 hours at a temperature high enough to allow water to separate out. Lightest fraction of oil distilled and condensed in water cooled coils. Heavy oil led by suitable pipes into second and then third boiler, lighter fractions of oil passing off first in each still. From third boiler oil passes into cast iron still and is distilled to dryness. Residue is oil-coke, a valuable fuel. Steam freely admitted during all distillations. Impurities remaining after distillation removed by stirring oil by compressed air with fixed quantity of sulfuric acid, allowing mixture to settle and removing mixture of acid and tar which separates. Oil then treated with solution of caustic soda, settled, and soda-tar removed. Acid tars steamed and washed, acid water used in manufacture of sulfate of ammonia. Tar from both treatments burned under stills and as liquid fuel is sprayed into furnace by air or steam jets.

186—ANON. Ponthierville Oil Shales. Mining World, *34*, 1182 (1911).

Brief mention of oil shales of the Congo, Africa.

Bitumens will yield 238 liters oil per ton. 30% petroleum, 20% light oils. Plant in construction to run 10 tons per day.

187—ANON. Transvaal Oil Shale Deposits. Mining World, *34*, 74-75 (1911); Petroleum Rev., *24*, 147-148 (1911); C. A. *5*, 783.

Describes briefly oil shales at Ermelo Wakkerstroom. Map of oil producing region in Transvaal. Principal deposits at Ermelo and Wakkerstroom. Ermelo shales average 32 gals. Small seam in Wakkerstroom yields 90 gals. Seam 9 in. thick. Australian shales run 60-120 gals. per ton.

	Ermelo Shales	
	Sp. gr.	Per Cent. yield
Naphtha	0.760	3.9
Paraffin oil.....	0.810	26.3
Lubricating oils.....	0.865-.890	30.7
Paraffin scale.....	...	10.1

188—BROWN, J. F. K. The Working of South African Oil Shales. South African Mining J., *9*, Pt. I, 352, 396 (1911).
Likens oil shales of Transvaal to carbonaceous shale and concludes there is little chance of development.

189—HURST, G. H. Lubricating Oils, Fats, and Greases. Scott Greenwood and Sons, London (1911). 3rd ed. 1917.
Contains chapter on Scottish oil shales, their distillation and process of treating the oils.

191—MORGAN, P. G. Greymouth Subdivision. Bull. 13, New Zealand Geol. Survey, p. 131 (1911).

192—TWELVETREES, W. H. The Tasmanite Shale Fields of the Mersey District. Bull. 11, Tasmanian Dept. Mines, Geol. Survey, p. 44 (1911).

193—ANON. Bituminous and Oil Shales in Canada. Mining and Eng. World, *37*, 202 (1912).
Albert mines comprise most important oil shale area of New Brunswick. They belong to Perry formation underlying lower carboniferous. Yields 27-48 gals. crude oil per ton shale, 50-82 pounds $(NH_4)_2SO_4$.

194—ANON. The Oil Shale Industry. Canadian Eng., *22*, 538 (1912.
New Brunswick shale yields 48 gallons oil per ton and 78 pounds $(NH_4)_2SO_4$. Describes Scottish practice. Upper portion of Scottish retort kept at 900° F., lower part at 1700° F. 80 gallons of water introduced at bottom as steam used per ton of shale.

195—ANON. Bituminous and Oil Shales in Canada. Mining World, *37*, 202 (1912).
Also calls attention to oil shales in Books Cliffs region, Colorado. Canadian Government paying considerable attention to shales. Economic deposits in New Brunswick, Nova Scotia, and Gaspé. Layers 3-7 ft. thick yield oil and NH_3. Analysis shows 27-28 gals. oil and 50-80 lbs. $(NH_4)_2SO_4$ per ton.

196—ANON. Prospecting the Transvaal Oil Shales. Mining Eng. World, *37*, 714 (1912).
At Mooifontein near Ermelo, 1000 acres contains bed from 4 to 5 ft. thick divided between coal and shale. Yields 30-40 gals. crude per ton. Deeper beds of shale will not yield oil in paying quantities. Shale beds near Wakkerstroom yield 60-90 gals. oil per ton but seams are only 18 in. thick. However, beds are quite extensive.

197—CALDWELL, W. Methods of Working Oil Shales. The Oil Shales of the Lothians, Pt. II. Mem. Geol. Survey, Scotland (1912).
Discussion of mining and crushing of Scottish oil shales.

198—CARRUTHERS, R. G. Geology of the Oil Shale Fields. The Oil Shales of the Lothians, Pt. I. Mem. Geol. Survey, Scotland (1912).
Part of bulletin by Scottish Geological Survey on the Oil Shales of the Lothians. Discusses geology of region and of shales based on work of H. M. Cadell and J. S. Grant Wilson.

199—ENGLER, C. Formation of the Chief Constituents of Petroleum. Petroleum, *7*, 399-403 (1912); C. A. *6*, 1221.
Process of polymerization plays important rôle not only in formation of different types of petroleum but also bitumens and is chief step in change of soluble fats, waxes, and resinous remains to insoluble high molecular weight bitumens. Breaking down of these bitumens by heat under pressure into soluble products is last stage in formation of petroleum. Anabitumens are bitumens in process of formation. Are esters of waxes, free fatty acids, and some hydrocarbons, and are soluble in benzol, carbon bisulfide, etc. Polybitumens are end products of anabitumens rendered insoluble by condensation and polymerization. To this class belong Austrian, Scottish and Autun shales and boghead coals. Katabitumens are portion of polybitumens made soluble by heat. Are semi-solid or liquid and converted into low molecular hydrocarbons with small amount of high molecular weight katabitumens and some anabitumens (fatty acids and fatty acid esters). Oxybitumens or asphalts are formed from ecognobitumens by condensation and polymerization.

202—STEUART, D. R. The Chemistry of the Oil Shales. The Oil Shales of the Lothians, Pt. III. Mem. Geol. Survey, Scotland (1912).
Discussion of method of retorting Scottish shales and refining oils.

203—TWELVETREES, W. H. The Tasmanite Shale Fields of the Mersey District. Tasmania Geol. Sur. Bulletin No. 11 (1912).
Bulletin of 123 pages discussing geology, location and economic importance of Tasmania shales. Yields, costs of production, and possible profits given.

204—YOUNG, C. A. Geology of the Moncton Map Area, Westmoreland and Albert Counties, New Brunswick. Can. Geol. Sur. Summary Rept., 316 (1912).
Oil shale and attempted development near St. John.

205—BASKERVILLE, C. American Oil Shales. J. Ind. and Eng. Chem., *5*, 73-74 (1913).
Mentions oil shales in Nevada, Montana and California. Indicates location of oil bearing shales in different countries.

206—CADELL, H. M. The Story of the Forth, Glasgow. Published by Messrs. James Macehose & Sons, Glasgow (1913).
Very interesting chapter (page 195) on development and working of Scottish Mineral Oil industry. Includes descriptions of fields and working of shales, and compares Scottish mineral oil industry with natural mineral oil industry. Excellent photographs and cuts of various pieces of equipment. (Subject matter covered in this paper read before Dundee Engineering Institute in 1910 and at Royal Society of Arts, January 16, 1911.)

207—CADELL, H. M. Scottish Shale Industry. Petroleum World, *10*, 228-236 (1913). Review of "The Story of the Forth" (Abs. 206).

208—ENGLER and HÖFER. Das Erdol, *1*, 35-37 (1913).
A classification of bitumen and bituminous material and a scheme explaining origin of all from a common source, *i. e.*, plant and animal fats, waxes, and residues.

209—LEE, G. W. The occurrence of Oil Shales among the Jurassic Rocks of Raasay and Skye. Nature, *92*, 169-170 (1913).
Jurassic oil shale occurs in northern Scotland.

211—M'KILLOP, G. E. The Vertical Retort of the Shale Oil Industry. Gas World, *58*, 340-341 (1913); C. A. *7* 1804.
(Paper read before Scottish Junior Gas Association.)
Principle clearly established that to get maximum yield shale must be heated slowly at low red heat and a current of steam passed through and maximum yield of ammonia obtained, after volatile matter had left shale, by strong red heat and liberal current of steam. Crude oil greenish brown and had gravity 0.86 to 0.88. No benzene homologues. Flue temperature 1100° C. at bottom, 800° C. at junction of iron and brick retort. Steam protects oil. Piece of shale to pass through retorting process in 70 hours. Condensed ammonia water—100 gals. per ton of shale.

212—REDWOOD, BOVERTON A. A Treatise on Petroleum, in 3 vols., 3rd ed., London (1913). *1*, 137-139; *2*, 83-139, 404-456 (Oil Shales, Occurrence and Development); *3* (Extensive Bibliography of Petroleum and Shales).
Kerosene shale of New South Wales more of the nature of torbanite. New South Wales Shale and Oil Co. distill 400 tons weekly. Australian Kerosene and Shale Co. distill 200 tons weekly. New South Wales, volatile hydrocarbons, 22.94% to 76.42%; fixed carbon, 7.04 to 26.79%; sulfur, nil to 1.304%.
New Zealand, volatile hydrocarbons, 64.67 to 81.79%; fixed carbon, 7.98 to 20.41%; sulfur, traces.
Gives short description of Scottish shale industry.
French shale oil industry: Shale broken into 4 in. cubes, placed in retort from which the spent charge has just been exhausted so that the distillation at once begins in strongly heated retort. Ammoniacal vapors come off first 3 or 4 hours; vapor becomes generally more charged with oil until after 12 hours, oil comes off for 8 or 10 hours. Retort distills one charge every 24 hours. Distillation of shale not carried to exhaus-

tion but is allowed to retain a little bituminous matter so that it may be used as fuel for next distillation. No super-heated steam used. Plamores refinery at Buxieres. St. Leger Refinery belongs to Société Lyonnaise. Latter produces from crude, 36.48% burning oil, 0.815 sp. gr.; 2.88% of "huile lampante," 0.860 sp. gr.; 1.49% lubricating oil, 0.886 sp. gr.; 25% green gas-oil, 0.895 sp. gr.; 20% tar, 0.96 sp. gr.; loss, 14.15%. Autun shales. 1 cu. meter shale produces 45 to 58 liters of crude oil of 0.89 to 0.90 sp. gr.; 50 to 60 liters ammonical liquor; 24 cu. meters gas.

213—SCHEITHAUR, W. Shale Oils and Tars and their Products. London (1913).
Translated from German by Charles Salter. Book discusses in detail shales and lignite. Gives history, occurrence, composition, working, utilization and detailed methods of manufacturing processes.

214—VON GROELING, A. E. The Scottish Shale Oil Industry. Engineer, *116,* 218, 251 and 275 (1913).
A series of articles on Scottish oil shale industry. First Scottish refinery opened in 1850 by James Young. Began to work shales in 1870. Specific gravity of shales 2.3 to 2.6. Yield 8 to 14% tar; 1.8% sulfur, 2/3 of which leaves with volatiles. Shales raised and crushed with toothed rolls 3 ft. in diameter and 9 ft. long. One pair crushes 200 tons per day. Development of present Scottish retort. Broxburn Oil Co. uses 384 Henderson retorts, Pumpherston uses 478 Bryson retorts. Broxburn has capacity of 1600 tons of shale per day. Little or no coal used at present; shale gas furnishes most of fuel. Henderson retort of new type works at 800-1000° F. Gas removed by suction and washed for ammonia and naphtha. Ammonia washers removed all but 5 grains per 1000 cu. ft. of gas. Wash oil for naphtha is 0.850 gravity mineral oil. Recovers 2 gals. of 0.730 gravity per ton of shale. Gas yield 3600 cu. ft. per ton of shale. Steam consumption should be about 20% of weight of oil.

Three kinds of naphthas are obtained, scrubber naphtha from washing the gas, condensing naphtha, and distillation naphtha. Continuous stills with preheaters and batch stills used. Distillation yields (1) light oil, (2) heavy oil, (3) heavy oil and paraffin, (4) coke. Heavy oil redistilled to yield (1) burning oil, (2) gas oil, (3) heavy oil and paraffin. Light oil of second and burning oil of third distillation redistilled to give the final products (1) burning oil, 0.785, (2) burning oil 0.800, (3) burning oil, 0.810, (4) residue. Burning oil treated with sulfuric acid and caustic before sale. Wax removed by cooling, pressing, and sweating. Special types of wax cooling apparatus described. Lubrication oils obtained from pressed wax, sp. gr. 0.865 and 0.885. Wax treated with charcoal and filters.

215—WOODRUFF, G. E. and DAY, D. T. Contributions to Economic Geology. U. S. Geol. Survey Bull., No. 581, Pt. II, 1-22 (1913).
Preliminary report on oil shale of Colorado and Utah, discussing character, physical properties of oil shales, various tests. Includes geological section and map.

216—ANDERSON, F. M. Oil Shales of Elko, Nevada. Am. Institute Mining Eng. Bull., 1402-1403 (1914).
Notes great percentage of organic matter in oil shales from Elko. States that no bitumens can be extracted by solvents such as chloroform and ether.

217—ANON. The Manufacture of Oils. Internal Combustion Engineering, *5,* 86-87 (1914).
A description with cut of Del Monte retort.

218—ARMSTRONG, J. T. The English Oil fields. Petroleum Rev., *30,* 383-5 (1914).

219—BALL, L. C. Tertiary Oil Shales of Baffle Creek, Port Curtis District, Australia. Queensland Govt. Mining J., *15,* 19-25 (1914).
Describes occurrence of oil shale and gives a few tests of the shale. Prevailing structural forms are anticlines and synclines. Thickness of beds not definitely known, probably 5-50 ft. Yield of oil, 10 gals. per ton shale; 20-37 lbs. ammonium sulfate. Kerogen here believed of animal origin. Analysis of shale shows a yield of 80 gals. and 270 lbs. paraffin wax per ton shale. Shale interbedded with barren shale and rocks.

221—BALL, L. C. Tertiary Oil Shales of the Narrows-Port Curtis District, Australia. Queensland Mining J., *15*, 73-76 (1914).

Describes occurrence and mining possibilities of oil shales. Narrow belt of soft sedimentary rock extends along Narrows. Mainland deposits extend northwest from a point on coast 3-4 miles west of mouth of Munduran Creek, nearly 16 miles distant to the south east. Extend inland from 1-2 miles. Numerous animal remains in shale account for high sulfur content. Oil light brownish-yellow to dark brownish-green. Low grade shales of Narrows notably unresistant to weathering. Largest yield oil is 28 gals.; highest nitrogen content, 0.42% (47 lbs. $(NH_4)_2SO_4$).

Analysis of shale samples:

Gals. Oil	12.5	21.4	8.9
Sp. gr.	1.88	1.5	1.47
Moisture	7.6	6.6	7.5
Volatiles	17.1	23.7	16.2
Fixed Carbon.....	4.5	6.1	2.5
Ash	70.8	63.6	73.8

222—BERG, G. The Scottish Oil Shales. Zeit. Prakt. Geol., *22*, 98 (1914); C. A., *9*, 1735 (1915).

Oil shale has sp. gr. 1.8 to 2.2, 1.5% sulfur and yields on distillation 7% of naphthalene, 29% illuminating oil and 17% fuel oil, besides lubricants and paraffins.

223—BROWN, J. F. K. Oil Shale Mining. Petroleum World, *11*, 164-168 1914); Iron & Coal Trades Rev., *88*, 352-3 (1914).

Discussed from investor's standpoint. Scotch shales are leathery; South African, Australian, and part of Canadian shales are gritty black rocks which scrape to dust when tried with knife. Scottish and Canadian shale strata much disturbed and broken. Australian and Transvaal shales are horizontal and regular for miles. Prospecting drill holes should be drilled on corners of 1000 ft. square, and careful records made. Little difference between shale and coal mining. Cost per ton under normal conditions, 3s 9d.-6s. per ton. Analysis of shale: Ash, 70.21%; volatiles, 25.30%; fixed carbon, 4.4%. Analysis of volatiles: Oil, 11.10%; water, 6.33%; gas and loss, 7.83%. From mines shales are raised to crushers, thence to retort, 60 ft. high, taper to bottom, being 4 ft. 8 in. by 1 ft. 10 in. in interior at base. Will pass 4½ tons shale in 24 hours. Upper part of retort is iron; lower part has firebrick lining. Distillate passes from top of tank into condenser, from which oil and ammonia run into separating vats. Permanent gases scrubbed with oil to take up any light volatile naphthas, and then with water to absorb ammonia.

Analyses of typical shales given in accompanying table.*

Costs dependent on location, country, and production. Average cost of manufacturing crude, 1s.6d. per ton. Refinery cost, ¾d. to ¼d. per gal crude. Sulfate of ammonia, 1s.9d. per ton shale.

224—CATLIN, R. M. Oil Shales of Elko, Nevada. Am. Inst. Mining Met. Eng. Bull., 1402 (1914).

Attributes Elko oil shale to saturation of shale by wax from oil which has escaped. Deposit is small and not like Scottish shales. Elko seam has rhyolite core. Thinks fluid oil escaped with waters of thermal springs which cross strata. Above rhyolite are found some oil shale seams yielding 10% low grade oil. Below rhyolite shale is darker and more massive; yields 25-30% oil, of which 30-40% is wax; contain no tars.

F. M. Anderson says: 75% of weight

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	Scottish	Scottish	South Africa	Canada	N. S. Wales	France	Spain	Russia	Serbia
Crude, gals....	21.40	40.00	35.00	40.00	101.00	40.00	60.00	70.00	45.00
S. of Am., lbs..	70	12	60	76	60	15	25	60	70
Naphtha, gals..	.68	3.36	5.21	1.45	8.48	2.15	.50	....	.50
Burn. oils, gals.	30.53	40.59	29.60	11.50	19.50	30.62	11.50	....	26.00
Inter. oils, gals.	1.78	.70	....	14.60	15.87	....	14.01	....	4.31
Lub. oil, gals..	27.26	16.83	33.00	11.03	22.80	15.01	13.59	....	12.02
Still grease....	....	2.47	....	....	....	3.0	....	....	....
Par'fin wax, lbs.	11.66	16.02	9.60	2.97	6.42	3.20	....	....	12.00
Still coke.....	....	....	....	....	....	....	....	....	....
Refuse and loss	18.23	26.03	22.59	....	....	....	....	....	....

of shale is of organic origin. Eugene Coste says: In Midlothians as well as in Elko shales are impregnated with petroleum in local spots only (where the volcanic rocks are) and not all over.

225—COSTE, EUGENE. Oil Shales of Elko, Nevada. Am. Inst. Mining Met. Eng. Bull., 1403-1404 (1914).
Concludes from evidence that wax or oil in Elko oil shales can only be there by impregnation and is of inorganic origin.

226—CUNNINGHAM-CRAIG, E. H. Petroleum Prospects in South Africa. Petroleum World, *11,* 265-271 (1914).
Describes geology of oil shale fields of Transvaal and Natal and tests of shale and gives estimate of cost.

227—ROBERTSON, J. B. A Chemical Examination of the Organic Matter in Oil Shale. Proc. Roy. Soc. Edinburgh, *34,* 190-201 (1914).
Examination of organic matter in Scottish oil shales. Ultimate analyses include C, H, N, and S. Shows that carbon-hydrogen ratio in oil shales is from 6 to 8 and over. Carbon-hydrogen ratio lower than in ordinary bituminous coals. Little resinous substance in shales. Nitric acid decomposed a great deal of the organic matter to CO_2 and oxalic acid. Ordinary solvents have little effect on shale. Organic matter decided to be similar to that found in peat and cannel coal.

228—TALBOT, F. A. The Oil Conquest of the World. Philadelphia, Lippincott, pp. 179-93.
Under the heading of "Oil from Shales; A British Industry," presents interesting popular description of the Scottish industry.

229—WELLS, JNO. Initial Equipment and Organization as Affecting the Ultimate Success of Oil Development Companies. J. Inst. Petroleum Tech., *1,* 47-71 (1914).

232—WRIGHT, W. J. Geology of the Moncton Map Area, New Brunswick. Can. Dept. Geol. Sur., Mines Summary Rept., 223-227 (1914).
Oil shales of Alberta area and distillation tests. Area includes 300 sq. mi. lying in basin of Petitcodiac River. Oil shales of Alberta region cover large area but are so distorted that it is difficult to estimate amount. Began working Alberta mines about 1849. Worked for 30 years. Difficulty with oil shale industry is that only low margins of profit yielded and companies hesitate to go into it. In 1913 a company made extensive investigations of property in this region but nothing came of it. For qualities of shales see tables of original article. Not known whether the Albert shales will decrease with depth. Little information written concerning amounts. Seams vary from 3 ft. 6 in. to 7 ft. in thickness. Records of Albert workings lost, so no information available. Albert mines were 1400 ft. deep. Victor shaft and East shaft 500 and 1000 ft., respectively. Predict shales sufficient to last a good sized plant 200 years. Salisbury and Albert railway gives direct connection with Intercolonial. If oil is pumped to steamer, the nearest point is Alma on the Bay of Fundy, about 25 miles south of the Albert mines.

233—WRIGHT, W. J. Moncton Map Area, New Brunswick. Can. Dept. Mines, Geol. Sur. Summary Rept., 101 (1914).
"Massive" and "curley" shales have been prospected and diamond drilled. Samples tested by Mines Branch, Dept. Mines, Ottawa, yield 39.45 Imperial gals. crude oil per ton shale and 67-110 lbs. $(NH_4)_2SO_4$ per ton. 36-ton sample retorted at Pumpherston Oil Co., Ltd., averaged 40 gals. oil (imperial) and 76.94 lbs. $(NH_4)_2SO_4$ per ton.

234—ANON. The Purification of Petroleum and Shale Oils and Waxes by Bauxite. Petroleum World, *12,* 80 (1915).
Describes methods used by the Oil Co., Ltd., Rangoon, India, and by the Anglo-Persian Oil Co. Bauxite used as purifying agent for wax and other products. Indian varieties of ore are best. In natural state has no purifying action; water of combination must be driven off at 500° C. before use. Oil first passing through bauxite filter is colorless, later becomes slightly tinged and then color increases until bauxite is exhausted. Bauxite will contain some oil after this process; bauxite is extracted and then steam dried, ignited, and used again in filter. British patents are held by Oil Refining Im-

provements Co., Ltd., 175 West George Street, Glasgow.

235—ATKINSON, A. A. Reports of Chief Inspector of Coal and Kerosene Shale Mines. New South Wales Dept. Mines Ann. Repts. (1915) for 1897-1910, 1898-1914.
Statistics of shale production in New South Wales in tons of shale mined and value for each year 1865 to date.

236—BALL, L. C. Oil Shale Industry. An introduction to a report on the oil shales of Lowmead now being prepared. Queensland Govt. Mining J., *16,* 608-616 (1915).
Oil shales distributed all over world. United States passed out of oil shale business when oil was found but is considering shales a future possibility. Brazilian enterprise failed because of too extensive works erected. Canada works stopped by American oils but development still contemplated. Scotland alone has weathered storm. Shales have been known to produce 120 gals. of oil per ton but present commercial yield is much less. $(NH_4)_2SO_4$ to the extent of 77 lbs. per ton has been produced; Scotland approaches this. Paraffin produced in large quantities from Queensland shales. Australian shales are not so hampered as others by foreign competition. History of shale industry given. Shales are found: *Africa,* Natal, Orange, Portuguese East Africa; *Asia Minor; Australia,* New South Wales, New Zealand, Queensland, Tasmania; *Europe,* Austria, Germany, Russia, Servia, Spain, Turkey, England, France, Scotland, Wales; *Canada; United States; South America,* Brazil. Are characteristics of no particular age. Ordovician shale in Galena Dolomite, Wisconsin. Utica shales of United States and Canada, silurian. Devonian shales in New Brunswick. Nova Scotia black shales, carboniferous. Permian shales reported in Brazil. Brazil coastal shales are tertiary. Oil shale generally fine grained rocks containing solid hydrocarbon and give paraffin and olefines on distillation. Are nature of saprophytic coal. Some believe that carbon compounds are in combination with clayey matter, as fuller's earth. Others think it is combined with sulfur $C_4(OH)_6O.O_2S$ as possible formula (Phil. Mag., *28,* 465 (1864), quoted by Twelvetrees). $CaCO_3$ is present in many shales. Most geologists are of opinion that they are of animal or vegetable origin. Scottish practice reviewed and products given.

237—BUTTS, C. Oil and Gas in Jefferson County, Kentucky. Ky. Geol. Sur., ser. No. 4, *3,* 238-241 (1915).
Short discussion, including analyses of shales from Kentucky and Indiana. Oil field of Kentucky shales (Louisville) 11.2 gals. per ton.

238—CROSS, ROY. Information concerning Shale Oil. Petroleum, Asphalt, and Natural Gas. Kansas City Testing Laboratory Publication, 116 (1915).
Statistics, tables, etc., showing costs, products, profits, etc.

239—CUNNINGHAM-CRAIG, E. H. The Origin of Oil Shales. Proc. Roy. Soc., *36,* 44-86 (1915).
"Oil shale is an argillaceous deposit from which petroleum can be obtained by distillation but not by trituration or treatment with solvents." Must be distinguished from impure coals by content of inorganic material. An oil rock is any rock or deposit impregnated with natural petroleum which can be extracted by disintegration of rock or by action of solvents.

Theory of oil formation: D. R. Steuart suggests that oil shales may be composed of (1) vegetable matter which has been made into pulp by maceration in water and preserved by combining with the salts in solution; (2) richer materials of many kinds such as spores which have been protected from decay; (3) a portion of animal matter. C. A. Seward believes that fresh water algae are a source of organic matter and suggests that structureless jelly-like mass might be formed by decomposition of such organisms. Spores also suggested but absence of resinous compounds is against this. Seward also hints at inorganic origin. Mr. deSalis suggests that heat of intrusive rocks may have caused natural distillation of hydrocarbon from coal seams but accumulation is not local.

Field evidence (Lothians): Notes that oil shales are a special and not a universal feature of the stratigraphical horizon in which they occur. Are not distributed over whole area in these shaley formations but are confined to certain

spots. Are found on crest or flank of anticlines. Shales decrease in richness as they go down anticline. Oil shales pass into carbonaceous shales. In certain cases oil shales associated with phenomena characteristic of oil fields. (South Africa) Structure is different from that of Scottish shales. No folding or faulting. Beds horizontal. Oil shales in coal measures are sometimes closely associated with coal seams. Sudden variations in coal seams rare. Type of shale very different from that of Scotland, more nearly approaches cannel coal. (New South Wales) Shale is of type of cannel coal and is associated with coals. Purest groups occur higher up. Oil shale passes into carbonaceous shale and impure coals. Structure horizontal. Gentle undulations where some of richer shale is found.

Evidence of oil fields: Definite stratigraphical relation exists between coal or lignite and oil-bearing formations and transition groups exist in which petroliferous and carbonaceous phases are evident. Oil naturally filtered by migration, leaving heavier, less volatile and especially unsaturated hydrocarbons. Inspissation may include oxidation and formation of unsaturated hydrocarbons but for practical purposes may be considered the removal of lighter constituents of petroleum leaving heavier. Evidence presence of manjaks in argillaceous rocks overlying rich and porous oil rocks. In New Brunswick is much evidence of past petroleum fields, and oil shale is present under conditions shown to be typical of oil fields.

Filtration absorption, and adsorption: Filtration through certain material absorbs certain constituents of oils or asphalts and renders them insoluble but they yield oil by distillation. Property of adsorption is property of colloidal state and shale mineral matter has much the same composition as Fuller's earth which is good adsorbing material.

Ammonium sulfate: All crude oil contains N_2 and N_2 bearing constituents are accumulated in inspissated part, thus yielding $(NH_4)_2SO_4$ on distillation. Same is true of sulfur.

Conclusions: Kerogen is formed by inspissation of petroleum and N_2 and S are concentrated in process. At certain stage in inspissation product becomes insoluble. Oil shale is formed by power of certain clays or shales to absorb and adsorb inspissated petroleum, particularly unsaturated compounds. Absorption and adsorption depend on colloidal content of argillaceous rocks.

241—DALTON, W. H. Bibliography of British Oil Shales (including Torbanites). Inst. Petroleum Tech., *2*, 178-182 (1915-1916).

242—DEBEQUE, G. R. Bituminous Shales of Colorado. Eng. and Mining J., *99*, 773-774 (1915).

Colorado shales in tertiary formation. Beds up to 80 ft. thick; Scottish beds 2½ to 16 ft. thick; French beds 4½ ft. thick; Scottish yield 30-40 gals. oil per ton, 25-35 lbs. $(NH_4)_2SO_4$. Poorer grades 18 gals. per ton and 60-70 lbs. $(NH_4)_2SO_4$. French shales 18½ to 21 gals. oil, 15 lbs. $(NH_4)_2SO_4$ per metric ton. Colorado shales 16-61 gals. oil, 22½ lbs. $(NH_4)_2SO_4$ per ton.

243—DEMESSE, J., and REAUBOURG, G. Sulphur-Containing Oil from the Kimmerage Shale of St. Champ, France. Bull. Soc. Pharmacol., *22*, 28-31 (1915).

Analysis of clay from Saint-Champ, France. Fe_2O_3, 2.6%; MgO, 3.3%; CaO, 45%; SO_3, .2%; P_2O_5, .2%; CO_2, 38.6%; oil and bituminous matter, 6.7%; water and loss, 1.4%. Analysis of oil (dry distillation) showed hydrogen, 9.2%; carbon, 77.3%; sulfur, 11.99%; nitrogen, .37%; oxygen, 1.14%. Separated into three parts—80-100°, 100-260°, above 260° C. First fraction, 7 cc., contains no S. Second fraction, 255 cc., corresponded to ichthyol of Bauman and Schotten. Above 260° contained S and is easily sulfonated. Brown oil has green florescence, peculiar odor, and sp. gr. 0.955 at 16.5° C. Insoluble in water and alkalis; partially soluble in cold ethyl alcohol, completely so in hot. Soluble in ether, acetone, carbon bisulfide, chloroform, benzine, carbon tetrachloride, and other oils and fatty matter. Possesses antiseptic and therapeutic properties which increase on sulfonation.

244—GLAZEBROOK, R. T., and others. The Viscosities of Oils in Relation to the Rate of Flow through Pipes. J. Inst. Petroleum Tech., *2*, 45-84 (1915-1916).

Results of flow experiments in 3 and 4-

inch pipes with shale oil and other oils. Temperature-viscosity curve of Scottish shale oil lubricant appended and some data included on viscosities of blends of Scottish shale oils with Mexican oil.

245—HOLDE-MUELLER. Distillation Products of Bituminous Shales—Shale Oil. "The Examination of Hydrocarbon Oils," New York, 282 (1915).

Scottish shale now yields 8-14% crude shale oil. Bituminous shale of Messel, 6-10%. Scottish shale oil: naphtha, 4%; oil distillate, 48%; crude paraffin, 12%; coke gas and loss, 35%. Messel shale oil: naphtha, 4%; oil distillate, 50-55%; crude paraffin, 12-15%; coke gas and loss, 33%. Water distilled contains about 0.6% NH_3. Pyrocatechol obtained from Messel shale. Scottish methods of distillation used on shales in New Brunswick and Nova Scotia. Resulting oil has sp. gr. 0.850 to 0.900, m.p. varies.

246—ISSER, M. The Occurrence of Asphaltic Shales in Tyrol. Petroleum Z., *10,* 578-80 (1915); Montan. Rundschaus, *7,* 267 (1915).

247—KEELE, C. Oil Shales at Albert Mines and Baltimore. Can. Dept. Mines, Mines Branch, Sum. Rept., 137 (1915).

Mentions possibility of using residue from oil shales for moulding purposes.

248—McGRATH, J. W. Oil Shales of Newfoundland. Petroleum Rev., *33,* No. 686 (1915); Can. Mining J., *36,* 493 (1915).

Deposits richer in oil than Scottish shales which yield 25 gals. per ton. Newfoundland shales yield 30-40 gals. per ton. In New Brunswick shales occur both in heavy masses and in formation known as "paper shales." The heavy massed shale in veins 800-1000 ft. thick. Yields 55 lbs. $(NH_4)_2SO_4$ per ton. At Gaspé in Quebec, shales are of Devonian age and are somewhat allied to shale formation of Newfoundland. Shales of Newfoundland give an allotrope of asphalt.

251—PERKIN, F. M. Oils, Their Production and Manufacture. J. Roy. Soc. Arts, *63,* 837-848, 869-875 (1915); Chem. Trade J., *56,* 96 (1915).

Scottish shale yields 23 gals. oil per ton. Industry started in 1847 when Dr. Plafair called attention of Dr. Young to oil seeps. Young distilled seeps until they were exhausted, then began distilling Scottish coals. Torbanhill or Boghead coals in West Lothian yield 120-130 gals. oil per ton. These coals worked about 12 years. Since then oil shale has been used. Young's process worked in America until 1859. Oil shales dark in color, laminated and horny fracture, 70% residue. Young's original shales contained 40-50 gals. In 1871 all companies produced 25,000,000 gals. In 1880 $(NH_4)_2SO_4$ went to £22-24 per ton, owing to the failure of the Peruvian guano deposits. In 1890 had dropped to less than £8 per ton and illuminating oils sold for 6d. per gallon. Plants were concentrated. Old retorts must produce 30 gals. to be profitable, new ones worked on 20. 3,000,000 tons shale worked annually. 275,000 tons oil produced annually, valued at £2,000,000. Yields following: Naphtha, 4,400,000 gals.; motor spirits, 600,000 gals.; burning oils, 20,000,000 gals.; gas and fuel oil, 120,000,000 gals.; lubricating oils, 10,000,000 gals.; paraffin wax, 25,000 tons; sulfate of ammonia, 55,000 tons. Temperature in Bryson retort, cast iron portion, 650-900° C. Article discusses carbonization of coals as well as shales for production of paraffin and oils. Generally speaking, though not always true, each per cent of volatile represents 1 gal. oil. Possible method is to distill at low temperature for oil and in second retort to distill NH_3 at high temperature. Experimental distillation of Scottish cannel coal by Del Monte retort as follows: moisture, 7.30%; volatile, 31.47%; fixed carbon, 36.93%; ash, 24.30%. Yields 37 gals. oil per ton. Approximate yield as follows: motor spirit, 1 gal. per ton; fuel oil, 6.3 gals.; heavy oil, 16.9 gals.; wax, 3 gals.; pitch, 12.4 gals. Tarless Fuel Syndicate retort has two vertical concentric cylinders. Material placed between them. Vacuum used. Yield on Newfoundland shales as follows: moisture, 1.45%; volatiles, 22.35%; fixed carbon, 2.92%; mineral matter, 70.65%; nitrogen, 0.24%; sulfur, 2.30%. Yield of oil 26 gals. per ton. Sp. gr. 0.92; oil to 150° C., 1.20%; oil to 250°, 16.50%; oil to 360°, 62.20%; residue, 13%; loss, 7%.

252—PONTE, G. Bituminous Shales of Sicily and their Industrial Impor-

tance. J. Soc. Chem. Ind., *34*, 165 (1915).
Shale deposits in Messina are easily accessible. Test of 150 kilos gave 7 to 9% of crude oil of sp. gr. 0.928 at 15° containing 3.4% sulfur and yielding 30% of light oil of sp. gr. 0.820 and 12% paraffin.

253—PULLE, G. Note on Oil Shales of Italy. Ind. Chim. Mining. Met. *2*, 209 (1915).
Describes occurrences and nature of oil shale in Italy.

254—SIMMONS, W. H. Lubricating Oils, their Composition. Petroleum Rev., *32*, 143-144 (1915).
Discusses shale lubricating oil as one of several products used in lubrication. Principal constituents of shale oil are hydrocarbon series of the paraffins and the olefines, latter predominating; also small proportion of naphthenes.

255—SPEISER. Bituminous Shales of Sieblos. Tonind. Ztg., *38*, 1517 (1914); C. A., *9*, 774 (1915).
An account of some bituminous shales in Germany. Analysis as follows: moisture, 3.4%; combined water, 6.6%; tar, 34.2%; non-combustible gases, 14.9%; ash, 25.6%.

256—STAUFFER, C. R. Devonian Shales of Southwest Ontario. Can. Geol. Sur. Mem. 34 (1915).
Discusses oil shales, page 258.

257—TINKER, C. K. and CHALLENGER, F. The Chemistry of Petroleum and its Substitutes. Crosby Lockwood and Son, London, pp. 182-192 (1915).
Includes chapter on distillation of bituminous shales. Reviews history of shale and development of retorts. Scottish industry began in 1850. Horizontal retort first used. Later changed to vertical to secure paraffin. Use of steam introduced. Steam increased liquid distillate and served several other purposes including yield of NH_3. Shale averaged 20-25 gals. of oil; 30-60 lbs. of ammonium sulfate. Sp. gr. of oil 0.860-0.890; contained 70-80% of paraffin and olefines. Distillation and refining methods and products described. Laboratory method outlined for determining oil and ammonia yield.

258—WHITE, DAVID. Regional Alteration of Oil Shales. Abstract in Bull. Geol. Soc. Am., *26*, 101-2 (1915).
Paper read before Geological Society of America. Examinations of "Oil rock" such as cannel coals and rich bituminous shales lying beneath a coal-bearing formation shows that organic matter of the shales, etc., is regionally altered, in general, and carbonized together with the coal.

261—ANON. Kimmeridge Oil Shales. Engineer., *121*, 85 (1916).
Oil yield good but sulfur content from 5-8%.

262—ANON. Gasoline from Shale. Oil Age, *12*, 16 (1916).
Discusses possibilities in shale as a future supply of oil.

263—ANON. Oil Producing Shales Possess Future Value. Oil Gas J., *14*, No. 41, 27 (1916).
Short article on shale industry and oil possibilities of the shales.

265—ANON. Petroleum Content in Green River Shale. Oil Gas J., *15*, No. 29, 18 (1916).
20,000,000,000 gals. oil in Colorado shales. Utah has about the same amount. Yields 10-15% gasoline on ordinary refining methods. Only small part of oil exists free in shale. Yields 40-90 gals. per ton.

266—ANON. Oil Shale Company for Utah. Salt Lake Mining Rev., *18*, 30 (Dec., 1916).
Utah Oil and Wax Co., $10,000 company holds right for Scott process in Utah, 35 gals. oil and 15 lbs. paraffin wax from 1 ton shale.

267—ANON. Future Gasoline Supply from Shale. Sci. Am., *114*, April 22 (1916).
When refined by ordinary methods shale oil yields 10% gasoline, 35% kerosene, and large amount of paraffin.

268—ANON. Vast Quantities of Oil may be Obtained from American Shales. Am. Gas. Light J., *105*, 420 (1916).
Vast quantities of shale in Colorado yield 10-15% gasoline on ordinary dis-

tillation. Average 42 gals. oil per ton. Some yield 90 gals. oil per ton.

269—ANON. Oil Shale in North Central Montana. Oil Gas J., *15*, No. 15, 26-27 (1916).
Shales belong to Kootenai formation. On top of this is Colorado shale. Oil yielding shales in northern part. Colorado shales of first importance in oil production. Gives geology of Montana. 2,350 to 2,650 ft. down to shales in some localities.

270—ANON. Newfoundland Oil Shales. Eng. Mining J., *101*, 436 (1916).
Shale yields average 30 gals. oil and 35 lbs. $(NH_4)_2SO_4$ per ton.

271—ANON. Kimmeridge Oil Shales. Engineering, *101*, 164-165 (1916).
Principal Kimmeridge shales in England in Dorsetshire. Shales mined by vertical shafts or inclined roads driven in on dip. Latter method opens up mine quicker but former method ultimately cheaper. Henderson retort developed in 1873 used spent shale and non-condensible gases for fuel.

272—BACON, R. F. and HAMOR, W. A. The Shale Oil Industry. American Petroleum Industry, 807-844 (1916). McGraw-Hill Book Co., New York.
A chapter devoted to oil shale industry giving distribution of shales in United States; historical sketch of shale oil industry, and description of Scottish methods and practice including mining, retorting, and refining.

273—CONACHER, H. R. J. Oil Shales and Torbanites. Geol. Soc. Glasgow, 164-190 (1916); Geol. Mag., *4*, 93 (1916); Petroleum Rev. Summ. *37*, 509 (1916).
Various materials in Lothian shales discovered by megascopic examination. (1) Carbonized bits of plants with occasional small spores; (2) yellow bodies believed to be algae, spores, or oil globules; (3) Shells of minute crustaceans and bones, teeth, and scales of fish; (4) Sand grains. Leavenseat shale,—portion richest in animal remains gave smallest yield of oil. Thorntonhall shales: upper layer contains both animal and vegetable remains. Lower contains only animal remains. Upper gives much greater yield of oil. Graigen Glen shale: Crowded with shells and yields 43 gals. oil per ton. Kimmeridge-Blackstone: Supposed ostracodas are minute lenses of calcite or siderite. Mass of rock made up of vegetable matter and minute crystals of iron pyrites. Yields 58 gals. oil per ton. Yellow bodies in foregoing tests considered vegetable matter. New Brunswick, Colorado and Utah shales do not have many yellow bodies. Boghead coal composed almost entirely of yellow bodies. Also small proportion of opaque amorphous matter filling interstices, occasional streak of bright coal or a sand grain. Greater the age of shales carrying yellow bodies the higher the oil yield and greater the proportion of opaque matter the higher the gravity of oil. Opaque material represents liquid putrefaction products of vegetable matter, whole of cellular structure having disappeared during process of decay in water. Opaque matter seems to be represented in Lothian shales by minute carbonized vegetable fragments. Author thinks tarry compounds, ammonia, and some paraffins originate here. Scouts Cunningham-Craig theory that yellow bodies are globules of oil, last relics of dried up petroleum. Nothing in common between oil shales and rocks known to be soaked with inspissated petroleum. Spore theory more probable but inconsistencies exist. Disproves algal theory.

Resin Theory. Resins abounded in vegetation of carboniferous period. Resin occurs in irregular masses if it has been formed as secretions from wounds; in needle-like rods if occurring naturally in canals of vegetation. Minute gas bubbles in resin may have given rise to some of the supposed "algal" structures. Fossilized resins are almost entirely insoluble, therefore the fact that resins are not dissolved out of shales is no sign that they do not exist there.

Conclusions: Valuable constituents in oil shales and torbanites do not come from animal matter. Oil yielding material consists of resin fragments. The N_2 present wholly or mainly in vegetable debris other than resin. No evidence to support view that petroleum has played any part in production of either torbanites or Lothian shales. Probable that dynamic metamorphism has some influence, other things being equal, on

yield and quality of oil; this point not fully investigated. Jones and Wheeler report that by extraction of common coal with pyridine and re-extraction of extract with chloroform, coal can be resolved into cellulosic and resinic parts. On distillation of former obtained phenols while latter gave paraffins, olefines, and naphthenes.

274—CUNNINGHAM-CRAIG, E. H. Relation of Shale Oil to Petroleum. Pet. World, *13,* 216-219 (1916); See abstract *277* for full paper.

275—CUNNINGHAM-CRAIG, E. H. Kerogen Shales. Chem. Trade J., *58,* 360 (1916). (Paper delivered before the Inst. Pet. Tech.). See abstract *277* for full paper.

276—CUNNINGHAM-CRAIG, E. H. The Origin of Oil Shales. Proc. Roy. Soc. Edinburgh, *36,* 44-86 (1916).

An oil shale is argillaceous or shaley deposit from which petroleum can be obtained by distillation but not by trituration or treatment with solvents. An oil rock is any rock or deposit impregnated with natural petroleum which can be extracted by disintegration of the rock or by action of solvents. (Broxburn shales yield 2.04% soluble in carbon bisulfide, *i. e.,* bitumen).

277—CUNNINGHAM-CRAIG, E. H. Kerogen and Kerogen Shales. J. Inst. Petroleum Tech., *2,* 238-274 (1916).

Kerogen shales are shales containing kerogen; kerogen defined by Crum Brown as substance or substances in Scottish shale that yield oil. Is neither petroleum, bitumen, nor resin but yields coals and Torbanhill mineral.

Microscopic Evidence: Oil shales contain yellow bodies of varying shapes and sizes and from these the oil is said to be produced. Several Scottish shales as well as those from South Africa and Bulgaria contain them. Decides that yellow bodies are not vegetable fossils of any kind. Are often spherical and do not disturb lamination like vegetable fossils. Evidence is that they were formed after beds were laid down. In torbanites or boghead coals kerogen seems to have developed in situ. In ordinary oil shales kerogen may have been largely introduced from an outside source.

Chemical Evidence: Steuart has shown that oil shale is soluble in CS_2 but insoluble in benzol. Oxygen content of kerogen shown to be that of a highly oxidized body. Carbon, 25.22%; hydrogen, 3.67%; oxygen, 5.65%; nitrogen, 1.14%; sulfur, 4%. Excluding N_2, S and ash: carbon, 73.05%; hydrogen, 10.62%; oxygen, 16.33%. Ratio of carbon to hydrogen in shales shows kerogen is similar to cannels and different from bitumens. Also related to bitumens derived from petroleum such as grahamite, albertite, and glance pitch.

Geological Evidence: In Scotland rich shales found on anticlinal structure decreasing in richness as they go down the sides. Abundance of organic matter lower on anticline with but little kerogen. Petroleum found in shales did not resemble oil from retorts. Torbanhill mineral does not occur in oil shale group but higher and is, therefore, more like coal.

Evidence from Oil Fields: Gilsonite, Barbados manjak, grahamite, wurtzilite, and albertite admittedly residues from petroleum but vary in bitumen content from 98-99 in gilsonite to 1-8% in albertite. Manjak veins extending to shale formations in Scotland's oil bearing series. Vein breaks into stringy small ones containing inspissated petroleum. Evidence shows manjaks or bitumens have been modified to form albertite and simultaneously petroleum impregnation similarly modified to form kerogen. Inspissation is process probably involving oxidation and polymerization. Filtration and adsorption by mineral matter probably had much to do with petroleum solidifying and holding kerogen formed. All petroleum contains N_2 and N_2 is concentrated in process of inspissation. Therefore, yielding of $(NH_4)_2SO_4$ evidence of inspissation. Properties of clays and shales. By comparison of numerous residues of oil shales with Fuller's earth shows that absorptive capacity of mineral matter may be deciding factor in whether given shale strata will become rich in kerogen.

Conclusions: Evidence presented proves that oil once existed in Lothians and the present oil shales are direct result of inspissation of the oil in shales.

278—DAVIS, C. A. Some Fossil Algae from the Oil-yielding Shales of the

Green River formation of Colorado and Utah. Bull. Geol. Soc. Am., *27*, 159-160 (1916).

Green River shales produce petroleum on distillation. In some cases yield greater than that of Scottish shales. Microscopic examination shows that they contain extensive flora of very minute algae and other cryptogamic plants.

279—DAY, DAVID A. Petroleum and Natural Gas. Mineral Ind., *25*, 532-67 (1916); *27*, 516-52 (1918); *28*, 489-533 (1919).

Review of production of petroleum and natural gas, accompanied by notes on oil shale.

281—DAY, T. C. The Cheese Bay Sill, Gullane. Trans. Edinburgh Geol. Soc., *10*, 249-60 (1916); Mineralog. Abstracts *1*, 58; C. A. *16*, 3051.

The field relations between basalt, shale and dolomite are described. At one locality the dolomite contains spots of kaolinite.

282—DEBEQUE, G. R. The Bituminous Shale Industry of Colorado. Eng. Mining J., *102*, 1011-2 (1916); C. A., *11*, 538.

Oil shale area about 20 by 50 miles in extent. Sample shows following analysis:

Sp. Gr.	1.6
Volatiles	36.14
Sulfur	.94
Nitrogen	.59
Ash	61.58
H_2O	.48

Shale yielded 51 gals. oil and 30.9 lbs. $(NH_4)_2SO_4$ per ton. Sp. gr. oil 0.916. Microscopic examination showed mixture of calcite and fine grained quartz embedded in mass of vegetable debris of cells, spores, wood, and pollen grains. Cresols, phenols, and flotation oil a possibility.

283—DUTOIT, A. L. Report on the Oil Shales of Impendhle Co., Natal. South African Mining J., *26*, 193-194 (1916).

Brief description of occurrence and character of oil shale in Natal.

286—ESPENHAHN, E. V. Kerosene Shale as a Gas and Power Producer. J. Gas Lighting, *135*, 398-400 (1916).

Review of literature and account of author's experimental work. Describes plant for making water gas from shale.

287—FORBES-LESLIE, WM. The Norfolk Oil Shales. Petroleum Rev. (Extract) *35*, 327-328, 347-348, 367-368 (1916); Petroleum World (Extract) *13*, 525-529 (1916); J. Inst. Petroleum Tech., *3*, 2-26 (1916).

Describes geology and tests oil shales of Jurassic age in Norfolk Co., England. Gives analysis of oil and shale. History of oil production in England. No oil in English shales younger than Jurassic.

288—FORBES-LESLIE, WM. The Norfolk Oil Shales. J. Inst. Petroleum Tech., *3*, 3-35 (1916); Engineering, *102*, 392 (1916).

English oil shales belong to Jurassic and Carboniferous system. Mentioned in parlimentary statutes of Queen Elizabeth. Worked in Phœnician times for some constituent not now known. Have been worked spasmodically for years. Scottish shale oil first worked by James Young in 1850. Worked torbanites. English shales cover large portion of south end of country. In England no bituminous or kerogen shales found in rocks younger than Jurassic. Gives detailed description of oil shale in this area. Two productive areas known, Smith and Puny Drain Series. Specimens from each area yield 50 gals. Shale from Smith series coarse-grained, dark brown and highly elastic, splitting along bedding planes into thin laminae. On exposing to sunlight loses moisture and becomes light but remains durable. Puny Drain shale grayish blue rock, prone to break into wide plates. Surface covered with calcareous fossils. On drying in air rock becomes light in weight and on percussion gives a note like wood. Microscopic slides made of Puny Drain series. In vertical section shows numerous lines or bedding planes. Numerous round spaces resembling mouths of loculi filled with organic material of somewhat lighter color occupy field. Part of field composed of yellowish resinous-looking substances, possibly form of kerogen. Yellow bodies are two distinct substances. Darker uniformly distributed throughout field, comprehending interval between bedding planes and stretching across them but not disturb-

ing laminations. Second class of material lighter. No vegetable fossils present and very few organisms. Sp. gr. Norfolk shales from 1.260 to 1.403. Oil is golden black, sp. gr. 0.942 to 0.960. Oil yield average (Puny Drain series), 50 gals. per ton. N_2 in shale, 1%; S, 6.4%. Shale yields oil at very low temperatures and residue contains 20 to 27% carbon. High sulfur content only drawback and this not serious. Large quantities of oil shale available.

291—IRELAND, J. B. Oil Shale Industry Planned for Utah. Salt Lake Mining Rev., *17*, 14-15, No. 24 (1916).

Outlines possibilities of development of oil shale in Utah and possible need of oil. Discusses John D. Scott process for distillation of shales.

292—MARSTRANDER, ROLF. The Mineral Resources of Uruguay. Mining Mag., *14*, 315-20 (1916).

Mentions among other minerals oil shale with the following properties: Fixed carbon, 6.6%; mineral oil, 8.7% (sp. gr. at 28° 0.912); gas, 2.5%; sulfur, 5%.

293—MANSFIELD, HARDY W. Oil Shales. J. Inst. Petroleum Tech. (London) *2*, 162-190 (1916).

Article deals with oil shales with special reference to those of the Kimmeridge series. Principal oil shale deposits of World. Australia, Wolgan and Capertee Valleys in the north; New South Wales, large deposit, richest in world, yield in 1912 was 86,000 tons; Across northern boundary similar shales on Queensland flank of McPherson Mts.; Tasmania, extensive deposits; Latrobe has prospects of being worked, also deposits at Nook Road; Canada, New Brunswick deposits rich in oil and NH_3, one of best deposits known as Albert shale (carboniferous), Saskatchewan, in Pasquia Hills near Carrot River, 50 miles north of railway, oil shales of Niobiaia cretaceous 150 ft. thick, yield 7 gals, crude and 22.5 lbs. $(NH_4)_2SO_4$ per ton; Nova Scotia, north side of East Bay, Cape Breton; Newfoundland, west coast near Deer Lake; Africa, in Transvaal (Karoo series), (Trias), cretaceous shales in Portuguese East Africa; Brazil, cretaceous shale in long coastal belt in northeastern part of Brazil; France, near Autun at Buxieres les Mines in province of Allier, 3/4 million tons per year being won, shales permo-carboniferous and low yield, elsewhere in France shales yield 80-90 gals. per ton; Germany, shales of triassic age occur in Württemberg; Spain, at Ronda, also north of Barcelona and in Castellon of varying but satisfactory yields. Serbia, Alexinatz; Great Britain and Scotland, shale mines chiefly at Linlithgowshire and Edinburghshire from seams in calciferous rocks, annual output 3/4 million tons, also in West and Mid Lothians and Fife, shales of Jurassic age in Islands of Raasay and Skye worth working; Wales, Flintshire coal measures; England, principal deposits in Kimmeridge clay in Dorsetshire, Norfolk and other regions, some exposed, others overburdened. History of industry discussed at length. Suggests Dorsetshire maps of Geological Survey for geological information.

Proves shales by boreholes along line of "strike" and at right angles to it on dip. Shales may be worked from vertical shafts or (in Scotland) from inclined road driven in shale on dip. Latter method quicker.

Quantity and quality of crude oil obtained from shale depends largely on temperature at which oil is formed and to which it is later exposed. Horizontal type of retort gave larger yield of light oils with correspondingly lower yield of lubricating oils and paraffin scale. Steam used later in vertical retorts increased yield and quality of crude. Henderson retort first to use non-condensible gases for fuel; also spent shale which contained 12% carbon was dropped into furnace to assist in heating succeeding charge. Young and Beilby retort introduced an innovation by heating partially spent shale to higher temperature thus increasing the gas and NH_3 yield. New Henderson retort on Young and Beilby principle but longer to allow shale to be exposed to heating surface for longer time. Charge supported at bottom on rollers revolving at regular rate which allows charge gradually to descend. For best yield and quantity of oil have temperature as low as possible. Del Monte retort heats from inside as well as outside by passing tube through center of charge which is fed through retort by spiral screw. No heat at lower one-third of the retort where charge enters. Larger yield and lower per cent of sulfur claimed

for this method. Tarless Fuel Co. (Tozer's patent) distill under vacuum to save time. Sulfuric acid necessity eliminated by Burkheiser method but sulfite of a Burkheiser salt must be changed to a sulfate if it is to be of use as fertilizer. Methods of removing sulfur from oil: Agitating with sulfuric acid (failed); submitting heated oil or its vapors to action of metals (partially successful); distilling with alkalis and zinc (failed); distilling through heated calcium carbide (failed); treatment with nascent hydrogen and precipitation methods (failed).

294—MANSFIELD, W. H. Oil Shales of England and Why no Use is Made of Their Oil. Petroleum World, *16*, 118 (1916). From a paper read before the Institute of Petroleum Technology, Feb. 15, 1916.

Kimmeridge shales offer great possibilities as a domestic source of oil. Great difficulty high content of sulfur. No successful method yet devised to remove sulfur.

295—MANSFIELD, W. H. Oil Shales and their Occurrence. Petroleum Rev., *34*, 159-160, 199-201 (1916). See Abstract 293.

296—NICKLES, J. M. Bibliography of North American Geology for 1915. U. S. Geol. Survey Bull., 645 (1916).

Literature on oil shales.

297—PARK, WM. E. News from Shale Fields in Canada. Oil Gas J., *14*, No. 43, 29 (1916).

Short discussion of late development of oil shales in New Brunswick, Nova Scotia, and Ontario.

299—SELWYN-BROWN, ARTHUR. Fuel Oil from Shale. Eng. Mag., *50*, 913-920 (1916).

Good general description of oil shale and its possibility as a source of oil. Albertite, solidified mineral pitch, color dark like hardened coal occurs in New Brunswick, gives 90-120 gals. and 80-90 lbs. $(NH_4)_2SO_4$ per ton. Tasmanite fossil wax found in Tasmania, yields 40-60 gals. crude oil per ton. Mining Tasmania shale costs $1.50 per ton; retorting, 60¢. Spent shale good fertilizer. Analysis of spent shale: Carbon, 10%; volatile, 1.1%; K, 5%; P, 0.19%; N, 0.17%; soluble material, 81.6%. Torbanite, found in Scotland and Canada. Some New South Wales torbanite yields 125 gals. per ton. Old shales contain less oil and more $(NH_4)_2SO_4$. Wood distilled: get acid; peat: get less acid; bituminous coal, still less acid. Distillate from torbanite only slightly acid when distillation begins and alkaline when finished. Describes Scottish products. Scottish refineries produce 2,000,000 gals. burning oil; 5,000,000 gals. naphtha; 22,000,000 gals. lubricating oils; 25,000 tons paraffin wax; 54,000 tons $(NH_4)_2SO_4$ per year. Australian shale (Blue Mts., New South Wales) yields naphtha, 8.48%; illuminating oils, 19.5%; gas oils, 15.87%; lubricating oil, 22.8%; wax, 6.42%; residue, tar and heavy oils, 24.65%.

301—SIMPSON, LOUIS. Oil-bearing Shales. Canadian Min. Inst. Bull., No. 54, 868-873 (1916).

Gives data regarding costs of mining and manufacture of shale-oil products with estimate of value of Canadian shales.

302—STEUART, D. R. The Oil Shale Industry. Soc. Chem. Ind., *35*, 774-76 (1916).

The review of the shale oil industry. Four plants in operation in the Lothians, Young, Oakbank, Broxburn, and Pumpherston. Total capital 3 million pounds; employ 10,000 men. One more plant at Philipston called Ross and Co. Shale measures under carboniferous and are 5 to 6 ft. thick. Paraffin manufacture started in 1850 on boghead coal yielded 90 to 120 gals. Shale yield 18-45 gals, and 35-70 lbs. $(NH_4)_2SO_4$. Put through 3,000,000 tons in 1915. Shale retorted at mine to save hauling. Oil is then sent to refineries. Permanent gases used as fuel. Mond gas used for auxiliary feed. Ammonia liquors distilled in vertical column, milk of lime introduced. Ammonia gas caught in H_2SO_4 which has been previously used to treat burning oils. Sulfate precipitated from solution and crystals centrifuged. Gravity of crude 0.965-0.880. Refining: fractional distillation and treatment of cuts with acid and caustic and sweating out wax from the heavy oil. Products: shale spirits, lamp oil, internal combustion engine fuel, fuel oil, gas oil, lubricating oils, paraffin, coke and $(NH_4)_2SO_4$. Acid carried down as black tar, pyridines, and unsaturated hydrocarbons, sulfur compounds, phenols, and benzene.

Besides these, substance apparently held in colloidal solution and precipitated by acids. Caustic potash takes down as black tar, phenols, sulfo-phenol, and acids. Tar washed free from acid and burned.

303—WHITE, DAVID. Some Relations in Origin between Coal and Petroleum. J. Wash. Acad. Sci., *6*, 189 (1916).

General consideration of theories of origin of coal and petroleum, and presentation of relationships between degree of metamorphism of various coals and character of petroleum found in same regions with them. Plankton imparts "fatty" quality to coals. If Plankton predominates in a coal, it is a boghead or oil rock, although if low in mineral sediments, it is type of cannel. If ash is much higher it is oil shale or bituminous shale. Kerosene shale of New South Wales, yielding 87% volatile matter, is hence true boghead.

304—WINCHESTER, DEAN E. Oil Shale in Northwestern Colorado and Adjacent Areas. U. S. Geol. Sur. Bull. (Contributions to Economic Geology, Pt. 2) No. 641-F, 139-198 (1916).

Describes oil bearing shales of region. Very complete geological discussion (with geological sections) and field tests showing kind and character of products. Chemical analysis included. Includes good bibliography on methods of mining and distilling oil shales in Scotland, France and New South Wales.

305—ALLEN, M. A. Future Source of Oil and Gasoline. Western Eng., Nov., 1917, p. 436; Gen. Elec. Rev., *21*, 73-77 (1918).

Statistics showing decrease in petroleum. Scottish industry reviewed. Rich shales produce 40 gals. per ton. Those worked at present produce only 20 gals. per ton. 32 million tons of Uintaite can be mined in Utah, yield would be about 134 gals. per ton. Also millions of tons of cannel coal can be mined in this country if ever profitable. Would yield 30 to 60 gals. per ton. Lignites, possible source of oil. North American shales expected to furnish oil in future. Nova Scotia and New Brunswick shales will yield 40 to 60 gals. per ton. Ammonium sulfate 67 to 110 lbs. per ton. Shale tars may be profitably cracked.

306—ANON. Shale Beds Hold Future Supply of Oil. Nat. Petroleum News, *8*, 19-20 (Jan., 1917).

Geological survey report a possibility of 20,000,000,000 bbls. of shale oil from Colorado shales and possibly more from Utah. Estimated costs per ton are as follows: Mining, $1.00; distilling, 40¢; $(NH_4)_2SO_4$, 46¢. Shale will run from 20-90 gals. per ton with 15-18 lbs. of $(NH_4)_2SO_4$. Oil from Green River formation should be from 17-35 Bé. gravity; should yield 6-12% gasoline, 28-49% kerosene, from 1.63-7.7% paraffin. Apparently no oil in shale as evidenced by fresh water springs with no oil coming from between shale ledges.

307—ANON. 20,000,000,000 bbls. of Oil in One State Await Distillation. Oil, Paint Drug. Rep., *91*, 48 (May, 1917).

Green River formation shale yields from 1-90 gals. per ton. In Colorado alone 20,000,000,000 bbls. of oil await distillation and 300,000,000 tons $(NH_4)_2SO_4$ can be recovered. Cost of mining Scottish shale is $1.00 per ton, cost of distilling crude 40¢ per ton of shale, cost of $(NH_4)_2SO_4$, 40¢ per ton. Scottish products: (1) fuel gas used in retorts, (2) naphtha, gasoline, and motor spirit, (3) lamp oil, (4) intermediate oil used for gas making, (5) lubricating oil, (6) solid paraffin, (7) still grease, (8) still coke, (9) sulfate of ammonia. Eastern shales are of Upper Devonian and Lower Carboniferous. Gives extent of beds.

308—ANON. Experimental Plant for the Extraction of Oil from Shale for Flotation. Chem. Met. Eng., *16*, 180 (Feb., 1917).

Company erected Henderson retort to extract oil for flotation purposes.

309—ANON. Continuous Distillation of Oil Shale. Mining Am., *75*, 3-4 (Dec., 1917).

Chew Process. Wood placed on fire grate of cylindrical still 18 in. in diameter and lined with fire brick. When wood becomes good bed of embers, shale crushed to pass 1 in. screen fed into retort. When first layer of shale is ignited, retort is completely filled with raw shale. Gases of combustion and distillation are withdrawn through a pipe inserted in top of

retort. Pipe leads gases to cold water condenser (ordinary steam radiator) where most of volatiles are liquefied and flow into small, cylindrical, galvanized iron air-cooled condenser. Pipe leading from top of this condenser carries gases and smoke to small blower which delivers gases and fumes to middle rectangular condenser unit. From middle condenser uncondensed gases pass to left hand condenser. When fumes reach hollow galvanized iron condenser they have temperature of the circulating water and exhaust from this condenser is little more than smoke. 1 ton shale yields barrel of oil by this process. Blower provides suction which draws outside atmosphere into burning shale on grate. Blower driven by gasoline engine.

310—ANON. Gasoline from Oil Shales. Chem. Met. Eng., *16,* 71-72 (1917).
Discusses reports from Geol. Survey. Oil yields 15% gasoline by ordinary methods.

311—ANON. Colorado Oil Shale Fields are Vast. Oil Gas. J., *16,* No. 29, 32-34 (1917).
States future economic position of shale oils. Quotes D. E. Winchester, Dr. Day and E. C. Woodruff to prove that quantities of good oil can be obtained from shales. Gives estimates of costs and profits, including dye manufacture.

312—ANON. Gasoline from Oil Shale. Chem. Met. Eng., *19,* 71 (1917).
Short article dealing with shale possibilities in United States as discussed by U. S. Geological Survey. Also shale possibilities in South Africa as expressed by South African Mining Journal, August, 1916, page 460, and October 28, 1916.

313—ANON. Scottish Oil Shale Industry. Engineer, *123,* 221-222, 274-275 (1917).
Deals with characteristics and general aspects of industry. Describes working of shales in Scotland.

314—ANON. A New Source of Gasolene. Mining Am., *75,* 3-6 (Dec. 22 (1917).
General information on Colorado shales. Description of Scottish products and map with locations. Wyoming and Colorado shale yield oil containing 20% gasoline; 18 lbs. $(NH_4)_2SO_4$. Government has taken 45,000 acres oil shale land in Colorado leaving 55,000 acres for private individuals. This has all been taken.

315—ASHLEY, G. H. Oil Resources of the Black Shales of the Eastern United States. U. S. Geol. Sur. Bull. No. 641 (1917).
Tests on samples from Indiana, Illinois, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia. Includes also some cannel coals. Most of shales tested yield oil but yield is usually low. Enormous quantities of shale in these states. Indiana alone could produce 100,000,000,000 bbls. of oil. Probably cost of oil from these low grade shales would be $4.20 per bbl.

316—BEVAN, THOMAS H. Scotland's Shale Oil Industry. Mining Am., *75,* 9 (1917); Petroleum World, *15,* 115 (1918).
Gives products and method. Shale distilled in 1916, 3,500,000 tons. Oil produced 300,000 tons or 80,500,000 gals. Motor spirit 660,000 gals. Naphtha 4,840,000 gals. Burning oil 22,000,000 gals. Gas or fuel oil 13,000,000 gals. Lubricating oils 11,000,000 gals. Wax 27,500 gals. Ammonium sulfate 59,400 tons.

American and Russian competition caused many shale companies to cease operation. Many improvements in retorting and refining. Good oil shale can be distinguished by brown streak, toughness, and resistance to disintegration by weather. Produces shale spirit or naphtha, sp. gr. 0.66 to 0.75 at 60° F.; burning oil, sp. gr. 0.77 to 0.83; gas or intermediate oils, 0.84 to 0.865; lubricating oils, 0.865 to 0.895; paraffin m. p. 100-130° F.; still coke and grease, still gases, sulfate of ammonia.

317—BROWN, J. L. Oil Shale Industry of Scotland. Coal Age, *12,* 401 (1917).
Discussion by B. Gibson, above reference pages 292-306. Short description of Scottish mining methods. Mention of products. Linlithgowshire yields 34% of total output of shale oil. Two seams of shale here, Broxburn, 6 ft. thick, Wee shale, 7-8 ft. thick. Seldom any fire damp in mines, considerable quantity of black damp.

318—DAY, D. T. Believe Shale will soon make up Deficit in Crude Production. Oildom, 7, 556 (1917).

Discussion of present shortage of gasoline and possibility of avoiding it. Discussion of shales as possible supply.

319—FORBES-LESLIE, WM. Hundreds of Millions of Tons of Oil Shales. Petroleum World (London), *14,* 61 (1917). (Taken from a paper "A True Oil Field under England.")
Each ton of Norfolk shales contains 30-40 gals. of oil. Three quarters is free oil and requires temperature of only 350° F. for extraction. Gives some geology of English shale beds.

320—GEORGE, R. D. Colorado Oil Shale Resources. Mining Am., *75,* 8 (1917).
Popular article on oil shale possibilities.

321—HENDERSON, J. Reffton Subdivision. Bull. 18, New Zealand Geol., Sur., p. 223 (1917).

322—HIGGINS, E. M. Shale Products' Possibilities in Industry. Mining Am., *75* (1917).
Colorado, Utah, Nevada and Wyoming shale yields 15-80 gals. oil and 15-30 lbs. $(NH_4)_2SO_4$ per ton. Recently in Scotland one year's run gave 280,000 tons, or 77,000,000 gals. crude; and 57,000 English tons $(NH_4)_2SO_4$. Crude oil distilled to dryness and coke left in still compressed to hard electric carbon used for making arc light carbons. Scientists and capitalists must work together for development of shale oil industry.

323—PHILLIPS, W. B. Texas Shale Oil is Known to be Rich in Gasoline. Kerosene and By-Products. Oil, Paint, Drug Rep., *91,* No. 17, 19 (1917).
Note on oil shale and lignite of Texas as a source of oil, $(NH_4)_2SO_4$ and gas. Discusses its place in increasing state wealth.

324—WAGNER, P. A. Mineral Oil, Solid Bitumens, Natural Gas and Oil Shale in South Africa. S. Afri. J. Industries, *3,* 29 pp. (1917); Rev. Geol., *1,* 356; C. A., *16,* 3840.
Occurrence of oil shale in British South Africa is described. Former existence of some petroleum indicated by veins of coal-like substance in certain localities. Terms pseudo-anthracite and pseudo-coal are proposed for this material.

326—WILLIAMS, M. Y. Oil Shales of Southwest Ontario. Can. Geol. Survey Dept. Mines, pp. 26E-28E (1917).
Oil shales of the Devonian series, Hamilton formation, color dark gray, black or brown. Outcrops at northwest extremity of Kettle Point, occurs above and extends below water level. Cleveland shales outcrop on north bank of Sydenbane River. Outcrop extends from below the water level to 10 ft. above. Nitrogen content 0.13-0.14%, equivalent to 15 lbs. $(NH_4)_2SO_4$ per long ton, or 13 lbs. per short ton. Commercial yield about 10-11 lbs. per ton. No distillation tests but approximate analysis shows 10 Imp. gals. per ton.
Cleveland shales 0.32% N_2, sp. gr. 2.5. Distillation test on 1500-gram sample to 654° C.: Gas, 1.1 cu. ft. or per ton 650 cu. ft.; oil, 18.5 grams, or 3 Imp. gals. per short ton; sp. gr. of oil at 22° C., 0.868.

327—WINCHESTER, DEAN E. Oil Shales of the United States. Econ. Geol., *12,* 505-518 (1917).
Oil shales in U. S. range from Devonian to Eocene age. Green river shales in Eocene. Good shales are black or brown and flexible, as distinguished from brittle carbonaceous shale. Shale of carboniferous formation in Kentucky and Illinois yields 20 gals. or less of oil. Shales in Colorado and Wyoming scattered through about 100 ft. of strata, 6 ft. or more of which will yield more than 40 gals. of oil, can be found most any place. Shales showing little vegetable content contain but little oil and those showing a great deal contain more oil, yet oil apparently does not come from vegetable remains. Cunningham-Craig's theory, therefore, not correct. Laboratory distillation gives 15% gasoline (175°), 33% kerosene (300°), with paraffin as high as 9.21%; asphalt, 2%; S, 0.61%; N_2, 1.7%. Viscosity of oil bears no relation to specific gravity.
Reviews Scottish distillation methods. Believes nitrogen bodies will be recovered for valuable dyes.

328—WIRTHMAN, FREDERICK G. Petroleum Shales. Chem. Met. Eng., *19,* 437 (1917).
Outlines commercial possibilities of Green River shales. Scottish yields 18%

of oil and 2% of $(NH_4)_2SO_4$. Colorado shales yield 42% of oil and 6% $(NH_4)_2SO_4$. Enough shale in Colorado to yield 20,000,000,000 bbls. of oil. Would expect shales to yield per ton as follows: 2 lbs. benzol; ½ lb. cresol; 1.4 lbs. phenol; 5 gals. gasoline; 25 gals. burning oil; 10 lbs. wax; and 100 lbs. $(NH_4)_2SO_4$.

329—ABRAHAM, HERBERT. Pyrobituminous Shales. Asphalts and Allied Substances, 158-164, New York (1918).

Pyrobituminous shales divided into two classes: (1) Asphaltic pyrobituminous shales in which asphaltic pyrobitumens (elaterite, wurtzilite, albertite) are associated with shales. (2) Non-asphaltic pyrobituminous shales, in which non-asphaltic pyrobitumens (cannel coals, lignite or bituminous coal) are associated with shales. Following means for differentiating: (1) by pyrobitumens found locally, asphaltic bitumens would indicate asphaltic pyrobituminous shales similarly, non-asphaltic pyrobitumens in the vicinity would indicate non-asphaltic shales. (2) By associated fossil remains. Vegetable fossils indicate non-asphaltic, animal or fish indicate asphaltic. (3) Effect of heat on solubility: On heating in closed retorts to 300-400° C. asphaltic bituminous shales will depolymerize and become more soluble in carbon bisulfide. Non-asphaltic remains unaffected. (4) Percentage of fixed carbon and oxygen, percentage of fixed carbon 2-25% in asphaltic pyrobitumens. Per cent of oxygen less than 3. Per cent of fixed carbon in non-asphaltic 5-50, per cent of oxygen 3-28.

Chapter gives location of various shale deposits of world.

Steuart obtained product resembling crude shale oil by destructively distilling mixture of lycopodium spores and clay.

331—ABRAHAM, HERBERT. Shale, Tar and Shale Tar Pitch. Asphalt and Allied Substances, 216-224, New York (1918).

Description of oil industry in Scotland. Mineral mined and hauled to surface, passed through breaker. Breaker consists of number of toothed iron rolls revolving in opposite directions. Shale passes from rolls to retort. Retort consists of four vertical cylinders mounted together with common hopper above. Upper portion of iron, lower portion of firebrick. Distillation takes place in upper part of retort at 900° F. Shale then raised to 1300° F. in lower portion, steam injected and NH_3 produced. Modern retorts essentially of four types: Pumpherston, Young and Fyfe, Henderson, and Del Monte. Vapor from retort passes through economizer and then to air condensers, then through scrubbers. Permanent gas burned in retorts.

Products: (1) Non-condensible gases, 3000 ft. per ton. (2) Ammonia liquor, yielding 45 lbs. $(NH_4)_2SO_4$ per ton. (3) Shale tar, 25 gals. (4) Light naphtha, 2 gals. (5) Spent shale, 80-85%, containing 2½% of carbon. Ammonia separated by heating with steam at 20-30 lbs. pressure in tower still; caught in H_2SO_4. Tar distilled and separated into various products.

332—ABRAHAM, HERBERT. Data. Asphalt and Allied Substances, p. 57, New York (1918).

Increase in solubility of shales upon heating given in accompanying table.*

*	% Before Heating	Temp. ° C.	Duration	Soluble in Benzol After Heating, %
Posidonomya shale from Reutlingen	0.6	250	24 hrs.	0.34
		300	Additional 24 hrs.	3.24
		400	" 24 "	0.00
Menilite shale from Strzytki, E. Galicia	0.85	300	½ hr.	1.21
		350	Additional hr.	0.70
		350	" 24 hrs.	0.40
Shale from N. S. Wales, Australia	1.4	250	2 days	1.33
		250	Additional 8 days	0.73
Shale from N. S. Wales, Australia	1.4	300	2 days	28.5
		300	Additional 8 days	7.8
Shale from N. S. Wales, Australia	1.4	400	1 hr.	4.9
		400	Additional 2 hrs.	44.9
		400	" 2 "	5.4
		400	" 2 "	0.0

333—ADKINSON, H. M. Oil Shales of Utah and Colorado. Salt Lake Mining Rev., *20,* No. 8, 22-25 (1918).
Discussion of present oil situation and government bureaus' activities in oil shale, possibilities of working shale, and discussion of Scottish practice.

334—ADKINSON, H. M. Colorado and Utah Oil Shale. Railroad Red Book, *35,* 5-7, 9, 11, 13, Sept. (1918).
Uintah Basin most important oil shale field because of nearness to railroads and because of ease with which shale may be mined. Production of oil from shale requires great initial expenditure for suitable plant. If our shale can be mined for 60¢ per ton business will pay handsome dividends. Oil sands mentioned. Gives history of oil shales in the U. S. and Scotland.

335—ALDERSON, V. C. The Oil Shale Industry. Quart. Col. School Mines, *13,* No. 2 (1918); Railroad Red Book, *35,* 15-24, Apr. (1918).
Bulletin devoted to shales and includes description of nature, origin, etc. Also description of Scottish shale oil industry, oil shales of Canada and other foreign countries. Detailed discussion of Colorado oil shale possibilities, including opinions by various government officials and oil shale men.

337—ANON. Development of Oil Shales to be Great Industry. Salt Lake Mining Rev., *20,* No. 5, 25-28 (1918).
A general discussion of oil shale industry as developing in Colorado and Utah. Enormous quantities of shale available. Impossible to state value of shale land but estimates it will yield 110,000 tons of shale per acre. Probable profit per barrel of oil, $6.75. Question as to whether Scottish retort will be suitable for these shales.

338—ANON. Oil from Shale Rock. Eng. Mining J., *106,* 419 (1918).
Oil shales in Utah, Colorado, Wyoming. Are heavier than coal, sp. gr. 1.6. Contain 50% ash. Good coal contains less than 10% ash. Some shale makes 2 bbls. oil per ton.

339—ANON. Oil Deposits in England and Wales. Iron and Coal Trades Rev., *97,* 642-671 (1918).
Principal shales in upper part of Kimmeridge clay but their presence must not be assumed in all outcrops of that formation. Kimmeridge shales cost more to distill than Scottish and products may be used only as fuel. Kimmeridge blackstone contains large amount S. W. T. Anderson says that Heyl and Mansfield exaggerate yield obtained from Kimmeridge shales. Oil distillate of this region contains 5.12 to 7.20% S. Analysis of Kimmeridge shale at Lincolnshire: NH_3, 0.05-0.06%; $(NH_4)_2SO_4$ per ton shale, 4.5 to 5½ lbs. (0.19-0.33%); heavy oils, 3 to 6.1%; light oils, 2.75 to 3.2%. Yield per ton shale, 1.3 to 16.4 gals. In volume 7 of Special Reports on the Mineral Resources of Great Britain is remark that discovery of mineral oil in Great Britain is trivial in importance because amount is so small. All genuine occurrences are from carboniferous rocks, majority from coal measures. In Cumberland occurrence of natural paraffin recorded, but yield has practically ceased. In sinking shaft in coal mine at Priorslee, Shropshire, rocks were so charged with petroleum that shaft turned into tar well. Present supply much decreased. Gives location, occurrence, extent, geology, and value of all known occurrences of petroleum in England and Wales.

341—ANON. Shale Oil in Pennsylvania. Natural Gas Gasoline J., *12,* 384-5 (1918).
Short discussion of production of "coal oil" in Pennsylvania before days of natural occurring oil. Last plant to be driven out by petroleum wells was Cannelton Beaver Co., which operated until 1872. Pennsylvania Geological Survey planning to do more work on Pennsylvania shales.

342—ANON. Will Shale Give Us Oil and Gasoline in Practically Unlimited Quantities? Manufacturers' Record, *74,* 85-86, Sept. 5 (1918).
Article giving information as to possibilities of shale being used as source of oil. Under certain high prices and shortage, shale can be depended upon to supply demand.

343—ANON. A New British Oil Industry. Nature, *100,* 506-507 (1918).
Oil possibilities of England discussed by Cunningham-Craig, Dr. Dunstan, and

Dr. F. M. Perkin. Sources include oil shale and cannels.

344—ANON. Utah Oil Shales. Salt Lake Mining Rev., *20,* No. 13, 26 (1918).
Pointed out by Andrew H. Northrup that Utah shales are more extensive and much richer than those of Colorado. Discusses commercial possibilities of Utah shales.

346—ANON. Scottish Mineral Oil Industry. J. Soc. Chem. Ind., *37,* 467 (1918).
Outbreak of war caused renewed prominence to be given to shale oil industry of Scotland. Number of companies decreased from fifty in 1860 to six in 1918. Principal products of industry: motor spirit, naphtha, burning oil, free oil, gas oil, oil, paraffin wax, and sulfate of ammonia. Wages chief item of cost in production. Shale miners' wages regulated by wages paid in coal trade. If high prices of coal hold, shale companies may experience financial difficulties. In last two or three years, oil of illuminating grade has been in demand as power fuel for motor fishing boats and farm motor trucks. Farmers having had practical experience in use of sulfate of ammonia, demand may increase in proportion to supply, thus keeping up price. Sufficient shale for many years' development.

347—ANON. Future Oil Supply Probably Assured by Resources of Shale Deposits. Eng. News, *81,* Sup. 167, Oct. 17 (1918).
Shows ample oil reserves in oil shale deposits.

348—ANON. Oil Shales of the West. Salt Lake Mining Rev., *20,* No. 2, 23 (1918). See Abstract 379.

349—LEACH, L. W. Products Obtained from Oil Shales. Mining Am., 4, April (1918).
List of products possible to obtain from shale oil.

351—BOWEN, C. F. Phosphatic Oil Shales near Dell and Dillion, Beaverhead Co., Montana. U. S. Geol. Sur. Bull., No. 661, 317-320 (1918).

352—BOWEN, RICHARD. Distillation of Coal and Shale and the Profitable Treatment of their Residues. Petroleum World, *15,* 119-121 (1918).
Article on saving of waste fuel products in general, with special attention to methods applied to shales. First 50% of oil distilled much more cheaply than last. Suggests leaving ⅛ to ¼ of oil in spent shale for fuel purposes.

353—CAMPBELL, A. E. Paraffin Wax and its Manufacture. J. Inst. Petroleum Tech., *5,* 109 (1918).
Complete description and discussion of manufacture of paraffin wax, with bibliography, large part devoted to the manufacture of wax from shale oils.

354—CARNE, J. E. Occurrence of Coal and Kerosene Shale in the Baerami and Widden Valleys, Goulburn River District, New South Wales. New South Wales Geol. Survey Dept. Mines Rept., pp. 155-8 (1918).
Brief report on shales of Goulburn River District.

355—CHASE, R. L. The Oil Shales of Colorado. Mining Sci. Press, *116,* 445-6 (1918).
Oil shales occur northern Colorado in Moffat, Rio Blanco, and Farfield Counties, covering an area of 2,500 sq. mi. and reaching maximum thickness of 2500 ft. Shales horizontal and interbedded with thin strata of sandstone; shales vary considerably in oil content, that of the richer beds varying from 10-90 gals. per ton. Many beds yield 17 lbs. of $(NH_4)_2SO_4$ per ton. Map of Colorado shale area.

356—CORYELL, P. C. Bituminous Shales of Colorado. Mining Am., 77, March 16 (1918).
Colorado shales first thought to yield worthless oil. Steam shovel cannot be universally or even generally used for mining shale because of thick overburden. Young and Beilby, and Henderson retorts are best types.

357—CROSS, ROY. No Gasoline from Shale, Expert Says. Nat. Petroleum News, *10,* 42-46, Jan. (1918); C. A., *12,* 762.
Shale oil will not make satisfactory gasoline without excessive refining losses; it is commercially adapted for fuel and illuminating purposes only. Only suc-

cessful shale operations are now in Scotland where less than 2,000,000 bbls. of shale oil produced in 1916 by six companies. Cross' examinations show that average good shale available in Colorado will yield 54 gals. per ton; this alone will not be profitable, but ton of shale will also yield 34 lbs. of $(NH_4)_2SO_4$, which will make industry attractive. Expected return from commercial exploitation of Colorado shale:

Proceeds per ton:
54 gals. oil (405 lbs.)...$2.70 (1918)

34 lbs. $(NH_4)_2SO_4$.....$5.16

Costs per ton calculated to be $4.34 for 1918. Little prospect that shale oil will replace petroleum in near future for any uses but as fuel oil.

358—CUNNINGHAM-CRAIG, E. H. Oil Producing Deposits of the British Empire. Petroleum Rev., *38*, 373 (1918).
Article pointing out the possibilities of oil in the British Empire. Discusses shales and torbanites as most likely source and describes shale deposits of Canada, Australia, New Zealand, and Africa.

359—DAY, D. T. Oil Shale Possibilities with some History. Salt Lake Mining Rev., *19*, 23-25, Mar. 15 (1918).
French shales yield 14-16 gals. oil per ton. Scottish shales 24 gals. and 30 lbs. NH_3 as $(NH_4)_2SO_4$, get 20% more for products than would at Denver. Yields 10-50% profit. 20,000,000,000 bbls. in Colorado shales, 2,000,000,000 bbls. of which is gasoline by ordinary refining methods. Utah has as much. Colorado should produce 300,000,000 tons $(NH_4)_2SO_4$. Scotland mines at cost of $1.25 per ton. Profit in Colorado shales if mining can be done at 60¢ per ton.

361—DONOHUE, J. L. Difference between Saturated Oil Sand and Oil Shales. Salt Lake Mining Rev., *20*, No. 2, 22 (1918).
Oil in oil sand is wrapped about each particle and can be removed by washing with solvents. Oil does not exist in oil shale but must be formed by destructive distillation of a complex material of an organic nature.

362—DORSEY, HAGER. Shales Assure Oil Supply for Several Generations. Eng. and Mining J., Jan., 1918.
States in the U. S. the industry is in its infancy.

363—EDITORIAL. Petroleum in Colorado. Eng. and Mining J., *106*, 413 (1918).
Petroleum resources of state described. Oil shale considered as a potential source.

364—EGLOFF, GUSTAV, and MORRELL, J. C. Supply of Oil Available from Shales. Oil Gas J., *17*, Aug. 9, 46-48; Aug. 16, 42, 44, 46; Aug. 23, 45-48 (1918).
Analyses of shales, cannel coals, and limestone. Details of origin of petroleum. Oil may be dissolved from some shales by carbon bisulfide, benzol, etc. Microscopic examination revealed yellow bodies in shale called kerogen, and yield of oil is proportional to their number. Distribution and mode of occurrence of shales over world. Treatment of shale in retorts. During retorting, distillate of oil and water was collected every 100 c.c. Tried to distill 100 c.c. per hour. Gravity of oil portion in first fraction higher than in the second and third portions, after then gravity increased again.

365—GALLOUPE, J. H. The Extraction of Oil from Shales. Mining Am., *77*, 6 and 16 (1918).
European methods not best for United States. Shale must be heated gradually, starting with very low heat and increasing until end of distillation period to secure maximum amount of liquid hydrocarbons. Each degree of heat generates different gas, thus reason for gradual heating. Steam does not increase oil yield but saves valuable quantity of N_2. Extensive tests made recently using a system of fractionating cells, apparatus having series of partitions to separate and keep gases apart along line of travel of shale from entrance to exit, grouping and fractionating oil into different parts. No steam used. Heavy oil, 40% of whole; grav., 20° Bé.; intermediate, gr. 28° Bé.; lightest, 34° Bé.

Cast iron furnaces of France not able to withstand high heat of Scottish retorts. Progressive distillation ending at

high temperatures noticeably augments yield of oil from shale of Buxieres and d'Autun.

366—GRABAU, A. W. Relation of the Oil Bearing to the Oil Producing Formation of the Paleozoic of North America. Bull. 1, Geol. Soc. Am., 92-93 (1918).

367—GREMPE, P. Seifenfabr., *38,* 597-8 (1918).
Popular article tracing history of oil shale activity in Germany and Scotland.

368—GUTTENTAG, W. E. Petrol and Petroleum Spirits. London, 1918, p. 49.
Brief description of Scottish industry, with discussion of properties of typical motor spirit of 167° C. end point. Total production of light distillates under heading of naphtha from Scottish oil industry given as 5,000,000 gals. annually.

369—HALDANE, J. S. J. Chem. Met. Soc., S. Africa, *19,* 1-6 (1918).
Results of experiments on dust inhalation. Shale and coal dust are harmless, and detach epithelial cells on which they alight, becoming eliminated from the system. Crystalline silica, on the other hand, as well as other crystalline compounds, is cumulative.

371—HALL, W. A. Gasoline can be taken from Oil Shale. Nat. Petroleum News, *10,* 50, Mar. 20 (1918).
Refute arguments of Dr. Cross that no gasoline can be obtained from oil shales. Only 2-3% gasoline made from Scottish shales because oil trade was well established before gasoline became important. French shales yield 15-18% boiling below 190° C. Yields 70-130 gals. oil. Scottish shales 16-23 Imp. gals. American shales could be handled at low temperatures and less cost. Scottish use high temperatures to get $(NH_4)_2SO_4$ (lower zone of retort 1500-1800° F.) Long time and low temperature runs yield saturated products. Scottish shale gasoline satisfactory motor fuel. American shales 3-6 times as rich as Scottish shales. In Scotland mining cost 4s. 10d. per ton. Shale oil contains 24% of excellent lubricating oil. Lamp oil 12-30%. 50% gasoline could be obtained by cracking.

372—HALL, W. A. Cracking of Scottish Shale Oil. Petroleum World, *15,* 337-340 (1918).
Shale oil must be cracked if gasoline in quantity is produced. French shale yields 15-18% gasoline. High temperature process used in Scotland. Low temperature process now being studied in England. Slightly more expensive but will increase value of products. Retorting is, in a way, cracking. Shale oil, while not so valuable as Pennsylvania crude, is certainly more valuable than California or Mexican oils. Shale oil can be successfully cracked. 50% gasoline can be recovered from shale oil.

373—HOSKIN, A. J. The Oil Shale Industry. Mining Sci. Press, *116,* 509-16 (1918).
Discussion with illustrations of areas of oil-yielding shale in Colorado, Wyoming, Utah, and Nevada, under captions: Geology of Colorado oil-shale area; character and varieties of shale; methods of distillation; fractionization and yield of gasoline, kerosene, etc.; prospective development; costs of operation; by-products; property rights; a manufacturing industry.

374—HOSKIN, A. J. The Oil Shale Industry. Western Eng., *9,* 191-198 (1918).
Great activity noted in industry in Colorado, Wyoming and adjacent territories. Map of DeBeque region given. Oil shales of that region in Green River formations. Oil not present as petroleum but is produced when shale is distilled. Good oil shales distinguishable from others by darker color, less gravity, and less weathered. Varieties: "paper" and "massive." Paper shales yield more wax. Methods of distillation: many researches devoted to method of distillation. Henderson, Young, and other Scottish types proposed. Numerous American processes being worked out. Products: DeBeque shale, 17½% crude oil, which tests as follows: 13% gasoline of 45° Bé. to 150° C.; 38% kerosene of 50° Bé. to 300° C.; 47% residuum of 16° Bé. to 400° C. Another test by a Kansas refinery: 48 gals. crude of 31.8° Bé. to 360° C.; analysis as follows: 15% benzine of 55° Bé. to 102° C., 10% distillate of 41.7° Bé. to 132° C., 20% gas oil of 34° Bé. to 194° C. Cost of equip-

ment, 100-ton plant, $50,000-$500,000. Mining at first will be cheap because shale exposed. Cost of operation: Crushing, from 7-35¢ per ton; mining on 100-ton basis, 40-50¢ per ton; underground mining, 20¢ more. Distillation, 12-65¢ per ton. Fuel all obtained from shale either as gas or by burning shale.

375—JENSON, J. B. Eduction Oil Shale Process. Salt Lake Mining Rev., *20,* No. 11, 23-26 (1918).
Discussion of development of shale work, adaptability of Scottish method to American shales, quality of shales and a description of Jenson horizontal retort or eduction plant. Discusses need of cracking.

376—JONES, J. B. Colorado, Utah, and Nevada Oil Shales. Oil Gas J., *16,* Mar. 28, 38; Apr. 11, 48 (1918).
History of Scottish shale oil industry and amount of products for 1916. Dividends 10-60% on invested capital. 39,000,000,000 bbls. oil in Colorado shales. Location and extent of American shales. Much rich shale is so overburdened with rocky material that mining costs prohibitive. Elko, Nevada, shales are near surface and close to transportation facilities. Costs of Scottish and American shale oil production compared. Tells how oil is produced. Gives number of plants and locations. Shale from Utah Co., Utah, yielded 110 gals. per ton. Elko shale: volatile, 31.6%; SiO_2, 52%; Al_2O_3, 7.4%; Fe_2O_3, 5.5%; CaO, 2.8%; MgO, 0.1%; N_2, 0.3%. Recovered 50 gals. oil per ton. Good gasoline content, large amount high melting point paraffin wax. Large per cent. lubricating oil gives greater refining value to shale oil than to well oil. Gas, 2000-4300 cu. ft. per ton. Analysis of gas: CO_2, 20.7%; O_2, 1.4%; C_2H_4, 3.1%; H_2, 16.3%; CO, 5.0%; CH_4, 40.2%; N_2, 13.3%. Heating value, 507 B.T.U. per cu. ft. or 1,039,350 B.T.U. per ton of shale. Spent shale made into paint pigment, silica for cement. 42 gals. oil per ton shale. Profit on 100-ton unit estimated as $4.50 to $5.44 per ton. Larger the unit the larger the profit. 300-1000-ton units yield $4-$6 per ton profit. In shale vein 30 ft. thick, averaging 2 bbls. oil per ton, 1 sq. mi. would yield 83,200,000 bbls.. Analysis of crude from Elko, Nevada: gr. 23.2° Bé.; 23% gasoline of 460° F. end point; 46% auto oil, 225 viscosity at 70°; 6% slack wax of 130.5 m.p. (unsweated); 10% asphaltic residue; m.p. 160-170°. Oil of above analysis yields $8 worth of products per bbl. Refinery report on Elko crude: 23% gasoline (460° end point) or 9.66 gals. per bbl., 46% lubricating oil, viscosity 225, or 19.32 gals. per bbl.; 5% paraffin wax, m.p. 130.5°, or 20 lbs. per bbl.; 10% asphaltic residue, m.p. 160, or 4.20 gals. per bbl. Value of products:

9.6 gals. gasoline at 18¢	$1.74
19.32 gals. lubricating oil at 25¢	4.83
20 lbs. paraffin wax at 10¢	2.00
4.2 gals. asphaltic residue at 5¢	.25
15 lbs. ammonium sulfate at 3¢	.45
	$9.27

Profit on 1 ton, $5.82, based on recovery of 1 bbl. per ton. 300-ton plant would have $1746 net daily profits. Shales from Grand Valley, Colo., reduced by Stallmann process, refined by Wells process will give similar yields and profits.

377—LEACH, L. W. Differences in Oil Shales and their Treatment. Salt Lake Mining Rev., *20,* 20-23 (1918).
Eight grades of black shales and eleven other commercial shales in DeBeque area. Best rich shales are those which weather either blue or white at outcroppings. Success of industry depends on right process for treating particular grade of shale. Two processes of distillation, destructive and so-called dry process. Destructive process is one in which shales retorted to obtain oil. Scottish process (Henderson type retort) decidedly destructive. In dry distillation shale placed in tight retort and heat applied does not itself touch shale enclosed. Here shale is retorted or steamed. German and Austrian ideas are along dry distillation lines. Shale should be ¼ in. mesh before retorting.

378—M'KILLOP, G. T. The Vertical Retort of the Shale Oil Industry. Chem. News, *117,* 280-81 (1918).
Traces development of shale retort to present day.

379—MITCHELL, GUY ELLIOTT. Billions of Barrels of Oil Locked up in Rocks. National Geographic

Magazine, *33*, 194 (1918). R.R. Red Book, *35*, 15-25 (1918).
Popular article on shale oil researches. Shows oil shales in Colorado, Utah, Nevada, and Wyoming, Kentucky, Ohio, Pennsylvania, Tennessee, West Virginia, and Indiana.

381—MOORE, HAROLD. Liquid Fuels for Internal Combustion Engines (1918).
A practical treatise for engineers and chemists. Chapter devoted to shale oils and products especially referring to utilization as fuels for internal combustion engines.

382—MORRELL, J. C., and EGLOFF, GUSTAV. Economic Position of Oil Shales. Chem. Met. Eng., *18*, 601-607 (1918).
Clay is argillaceous or sedimentary deposit still containing enough moisture to be plastic. By loss of this uncombined water clays pass into mudstones, shales and slates. Analyses of clays, limestones, shales and cannel coals. Asphalt from pitch lake has following composition: carbon, 82.33%; hydrogen, 10.69%; sulfur, 6.16%; nitrogen, 0.18%. Tabulates properties of gilsonite, tabbyite, wurtzilite, ozokerite and rock asphalt. Properties of shales and cannel coals approach wurtzilite but differ from it in being insoluble in carbon bisulfide. Discussion as to distribution. Average of 131 samples of American shales gave 19.2 gals. oil per ton and 16 lbs. of $(NH_4)_2SO_4$ while 44 samples from Canada give 34.9 gals. of oil with 51.3 lbs. $(NH_4)_2SO_4$.

383—MORRELL, J. C., and EGLOFF, GUSTAV. Oil Shales, Albertite, and Paper Shales. Chem. Met. Eng., *18*, 112-113 (1918).
Correction on previous paper (Abs. 382) and an addition on theory of origin of petroleum.

384—MORRELL, J. C., and EGLOFF, GUSTAV. Destructive Distillation of Oil Shales. Chem. Met. Eng., *19*, 90-96 (1918); C. A., *12*, 1924.
Oil shales are probably of same origin as crude petroleum. Bituminous shales produced by slow evaporation of impregnated oil, vegetable, and animal matter in clays before or after being consolidated into shale. Per cent of unsaturates in distillation fractions of shale oil showed two maxima and one minimum. First 10% contained 32%, the 20-30% fraction 24%, and the 80-90% fraction high value of 50% unsaturates. Small per cent of C_6H_6, $PhCH_3$, and $Ph(CH_2)_2$ were found in the oils examined. PhOH, o- and m- cresol, xylenols and guaiacol comprise list of phenols so far identified in shale oil. Pyrrol, pyridine, picoline, luditine, and parvoline have been identified also. Shale oil industries of France and New South Wales have declined or failed to advance. Average yield of oil from U. S. found to be about 20 gals. per ton. Naphtha fraction of nine samples was about 10%. This product unsuitable for use in gasoline engines and cannot be refined by usual H_2SO_4-NaOH process. Scotland has averaged less than 1% marketable gasoline from shale oil in last 50 years. U. S. shale oil will certainly yield very much less than 10% marketable gasoline. Certain that oil shales will be of great economic importance in years to come. At present, no large retorting plant is in operation, and problems of the future are largely unsolved.

385—RUSSELL, WM. C. Commercial Possibilities of the Oil Shale Industry in Colorado. R. R. Red Book, *35*, 15-18 (1918).
In 1917 U. S. drew on its reserve supply of oil to the extent of 21,000,000 bbls. Scottish companies pay dividends averaging 15% on capital stock (before war). Profits were $1.00 per ton. Deposits 500-1500 ft. below surface are from 2-7 ft. thick. Scottish methods efficient but antiquated; capital outlay in construction so great that it is not expedient to modernize equipment. Colorado deposits 6-22 ft. thick lie far above valley floors. Belong to Green River series, tertiary period, contain no liquid oil, have paraffin base. Temperature of distillation should not exceed 900° F. Enough non-condensible gases to furnish all fuel plant consumes. Scottish shales must have the aid of some other fuel. Shale oil cracks more easily than well oil, requires lower temperature, produces less permanent gas. Gasoline cut from Colo. shale 16%, shale oil gasoline has a higher caloric value, gives 15-20% more mileage in motor cars. 50% of crude shale oil can be cracked into

gasoline. Several times greater gasoline content than Scottish shales. M. P. of Colo. shale paraffin wax 135-140° F. May be sold in suspense for 75% of refined value. 1 ton water required for distillation of 1 ton shale. Nearness to water and transportation, sufficiency of capital, large daily throughput, cost of mining, retorting, and refining, and proximity to market essential for success. After retorting comes expense of refining. Oil too heavy to be piped so tank cars must carry it to refinery. To produce oil in paying quantities requires plants capable of handling 1000 tons per day. Cost of such plant not less than half million dollars.

386—SPENCE, H. C. E. Oil Shales of Pictou. Bull. Can. Mining Inst., 928-31 (1918).

Description of Pictou area and shale outcrops. 500,000,000 tons of shale, 80-100 ft. thick; 40 gals. oil and 79 lbs. $(NH_4)_2SO_4$. Two varieties of shale: cannel shale, 18-20% fixed carbon; curley shale, 5-7% fixed carbon, 5-6 ft. thick, 60-75 gals. of oil, 35 lbs. $(NH_4)_2SO_4$; average 40-70 gals. of oil per ton.

387—STANSFIELD, EDGAR and NICOLLS. Analysis of Canadian Fuels; Maritime Provinces. Canada Dept. Mines, Mines Branch Bull. No. 22, 28 (1918).

Proximate analysis New Brunswick shale: Moisture, 4.4%; ash, 73.9%; volatiles, 17.3%; fixed carbon, 3.9%. Ultimate analysis: Sulfur, 0.2%; nitrogen, 0.8% (81 lbs. $(NH_4)_2SO_4$ per ton). Calorific value 2110 B. t. u. per lb. Destructive distillation yields 4.6% by weight, or 12.4 Imperial gals. per ton.

388—STRAHAN, A. Special Reports on the Mineral Resources of Great Britain. Vol. VII Lignite, jets, Kimmeridge oil shale, mineral oil, cannel coals, natural gas. Part I, England and Wales 1918. 2nd. Ed. *1920,* 59-71.

Distribution, uses, value and analyses of Kimmeridge oil shales.

389—STRAHAN, A. Kimmeridge Oil Shales. Colliery Guardian, 1136-37, Nov. 29 (1918).

Geological; geology and extent of Kimmeridge shales.

392—SUNDERLIN, E. A. A New Process Treatment of Oil Shale. R. R. Red Book, *35,* 13-16, June (1918).

Detroit Testing Labs. erecting shale oil plant for General Eduction Co. in Utah. Scott process used has two separate and distinct stages. 20 tons per day as compared with 4 tons by usual retort methods. To condense into oil the vapor and gas, rotary jet condenser eliminates necessity of surface condensers of many feet of iron pipe. Cooled oil used as condensate by means of finely divided spray from condenser impeller, which is impacted against gas with high velocity in its flow through condenser chamber. NH_3 separated from oil after condensation. Gas remaining after condensing oil delivered to special form of NH_3 scrubber where it is brought into intimate contact with water by alternately passing through water sprays and mineral wool filters. Potash in spent shale to be recovered by repeated washing with same water until saturated solution results.

393—TWELVETREES, W. H. The Bangor Mineral District. Bull. 27, Tasmanian Dept. Mines, Geol. Survey, p. 16 (1918).

Short description of oil shale deposits.

394—WADLEIGH, F. A. Treatment of Oil Shales in Colorado. Eng. Mining J., *105,* 917 (1918).

Wingett furnace capable of treating 150 tons of shale per day consists of four circular chambers and four retort chambers, arranged alternately, forming a cylinder approx. 30 ft. high and 12 ft. in diameter. Two air-tight steel tanks on top contain crushed shale which is fed automatically onto revolving table in top retort chamber and is continually agitated while exposed to heat. Each retort chamber contains similar table, which revolves on main shaft extending from base to top retort chamber. Process repeated throughout three other retort chambers, and provision made to regulate heat in corresponding combustion chambers, so that when shale finally drawn off by screw conveyors at bottom, estimated that 95% of valuable constituents are extracted. Furnace operated in vacuum and gases drawn off by vacuum pump into water-cooled condensers from which oils are collected into storage tanks.

395—WAGNER, P. A. Petroleum and its Prospects in South America. Petroleum Rev., *38,* 75, 107, 157 (1918). Mining Mag., *18,* 46-48, Jan. (1918).

Shale occurrences described and results of tests given. Scottish shale oil industry developed over an area of 6 by 15 miles. Thickness of shale 1-12 ft. Yields 18-40 gals. oil and 8-80 lbs. $(NH_4)_2SO_4$. Old type of retort must yield 30 gals. per ton to be profitable, new one works on 20. Old type of retort yields 16 lbs. $(NH_4)_2SO_4$; new type, 35-70. Loss of from 20-27% in refining. In 1913 yield averaged 22 gals., 45 lbs. $(NH_4)_2SO_4$, 15 lbs. wax. French shales yield 12 gals. oil. Beds 2 to 2-½ meters thick. South African oil shales found in Karroo formations. Data show that they are workable: Some South African shales yield 30-32 gals. oil and 64 lbs. $(NH_4)_2SO_4$. Will yield 6 lbs. of paraffin wax per ton. Shales only 3 in. thick found near Wakkerstroom yield 90 gals. oil. Oil averages 40-60 gals. Also yields 13-20 lbs. $(NH_4)_2SO_4$.

396—WALLACE, G. W. Shale Oil Plant on New System. Petroleum World, *15,* 462-64 (1918).

Description of Ute Oil Company's plant being erected near Watson, Utah. Wallace retort used. Capacity 400 tons. Experimental results on Utah shales given.

397—WILCOX, W. F. Mountains of Oil in Colorado. Tractor and Gas Engines Review, *11,* 10, Mar., 1918; Sci. Am., *119,* 29, July (1918).

Colorado shales may be mined with steam shovel and dropped by gravity to treating plant. Tests by experts show that Colo. shale yields higher per cent of gasoline, motor spirit, and kerosene and equal per cent of lubricating oils and gas, as compared with Scottish shales. Phenols present in commercial quantities. Shale oil excels as flotation oil in treating minerals. New York chemist and analyst says ton of shale yields 2.66 gals. gasoline, 5.23 gals. kerosene, 17 lbs. wax, 43.2 gals. fuel oil, and 36.4 lbs. crystalline $(NH_4)_2SO_4$.

398—WINCHESTER, DEAN E. Oil Shale of the Uinta Basin, Northwestern Utah, and Results of Dry Distillation of Miscellaneous Shale Samples. U. S. Geol. Survey Bull. No. 691, 27-55 (1918).

Oil shales of northwestern Utah; map showing distribution of oil shales in region; geological sections and microscopic photographs of shale; numerous distillation tests on shales showing yields of hydrocarbons and by-products. Nitrogen content given. Mentions commercial possibilities of production of pyridine compounds. Opinion that oils are not inspissated petroleum but are formed by the destructive distillation of vegetable matter contained in shales.

399—WOLFF, H. J. Commercial Aspects of the Shale Oil Industry. Western Eng., *9,* 222-23 (1918).

R. D. George states no company should operate under 100 tons daily capacity. Should have capital of $2,500 per ton. Scottish shale oil plants have decreased in number from 50 to 6 and are now treating 2000 tons daily. Industry cannot be compared to petroleum production but better to petroleum refining. 1 ton of water required to treat 1 ton of shale. Altitude of Colorado shale lands about 8,000 ft.; water scarce. Oil shales not containers of oil but yield oil on distillation. Can be mined about the same as coal or at a cost of $1.18 per ton. No operations should be begun on less than 10 sq. miles. Should obtain on an average 50 gallons of oil, 41 lbs. $(NH_4)_2SO_4$. In Scotland 80-200 lbs. of coal used per ton shale. Not necessary here because shale produces gas enough. According to Mr. Pearse, industry is more highly developed in France than in Scotland. Spain, Brazil and Australia are starting developments.

401—ALDERSON, V. C. The Oil Shale Industry. Am. Mining Congress, St. Louis (1919).

Review of petroleum situation and possibilities of shale supplying future demand. Due to the increased demand for petroleum and exhaustion of wells in near future shale will compete favorably. Oil shale industry not poor man's game. Successful plant must have at least 400 tons daily capacity. Investment should not be less than $500,000. Favorable features of oil shale industry: enormous extent of deposits, great thickness of both medium and high grade shales, expos-

ures above levels of creeks makes mining costs low, adequate water supply for condensing and cooling, accessibility to railroads and markets, richness of shale.

402—ALDERSON, V. C. The Oil Shale Industry. Boston News Bureau, 5, Nov. (1919).
Popular article discussing activities in shale work.

403—ALDERSON, V. C. The Shale Oil Industry. Quarterly Colo. School Mines, *14,* No. 4 (1918).
Bulletin devoted to shales including general description of shale possibilities and development, discussion of composition of oil shale and shale oil by C. W. Botkin and of the production of shale oil by John C. Williams.

404—ANDERSON, LEE and DINHAM. Oil Shale Resources of Scotland. Iron Coal Trades Rev., *99,* 540 (1919).
Review of shale resources of Scotland which show that at present rate of working shale will last one hundred and thirty-three years.

405—ANON. Production of Gas from Bituminous Shale. J. Gasbel., *62,* 774-6 (1919).
100 kilograms of Württemberg shale will yield 15 cu. meters of gas and 2 kg. of tar. Gas analysis: 9% heavy hydrocarbon, 39-40% H_2, 7-8% CH_4, 7-8% CO, 14-15% CO_2. Burned residue may be used to make brick.

406—ANON. Investigation of the Shale Oil Industry. Eng. Mining J., *108,* 480 (1919).
Note on recommendation of Secretary of Interior to Senate committee on appropriations for shale work.

407—ANON. Expert Information on Oil Shales. Oil Gas J., *18,* No. 62, July 25 (1919).
Substance of address by Mr. Joseph Bellis discussing shale mining, retorting and refining.

408—ANON. Distillation of Oil Shale in Germany. Eng. Mining J., *108,* 694 (1919).
Pre-war one company was distilling oil shale at Reutlingen. Lately bituminous shale near Messel has been worked; yields per ton 32 gallons crude oil and 1900 cubic feet gas.

409—ANON. Irish and Scottish Oil Shale. Eng. Mining J., *108,* 872 (1919).
Geological and mineralogical character of deposits of oil shale of Scotland and Ireland.

411—ANON. Oil Shale Deposits in the United States. Automotive Industries, *40,* 798 (1919).
Brief mention of shale oil and its possibilities. Note on Scotland's industry.

412—ANON.—Report of Test of New Brunswick Shales in the Wallace Retort. Chem. Met. Eng., *22,* 809-10 (1919).
Description and cut of Wallace retort. Test on 81 lbs. New Brunswick shales summarized as follows:

	Per ton of shale.
Oil recovered	43 U. S. gals.
Gas	4,290 cu. ft.
Spent shale	1.297 lbs.
Temp. of retort	240 to 820° F.
Temp. of combustion chamber	1480 to 1540° F.
Temp. of reduction pipe	500 to 810° F.

413—ANON. Liquid Fuels. Petroleum World, *16,* 305 (1919).
Discusses briefly Kimmeridge shales as source of oil and mentions sulfur as a difficulty to be overcome.

414—ANON. Oil Extracted from Scottish Shale. Oil Gas J., *17,* No. 45, 60; C. A., *13,* 1389 (1919).
Reviews Scottish industry including retorting and refining.

415—ANON. The Oil Shales of Northwestern Colorado. Bureau Mines State of Colorado, Bull., 8, 59 (1919).
General discussion of Colorado shales.

416—ANON. New Method for Distilling Crude Oil from Shales. Oil, Paint, Drug. Rep., *95,* 60 A, No. 1 (1919).
New method of distilling crude oil from shale perfected by Geo. W. Wallace by which it is claimed as much as 85 gals. of oil was obtained per ton shale. (U.

S. Patent 1,283,000.) Expects average to run 44 gals. Surrounds shale by fire instead of submitting it to heat from below. Temp. 1050°. Experiments carried on at East St. Louis Gas Light and Fuel Co.

417—ANON. Oil Shales in Colorado and Utah. Petroleum Rev. New. Ser. (London), *36*, 85 (1919).
Government reports 20,000,000,000 bbls. oil in Colorado and Utah shales. Oil from shales much like oil from wells. Gravity at 70° from 17-35° Bé. Fractionation of shale oil revealed uniformity of products: 6-12% motor spirit; 28-49% kerosene; 1.63-7.70% paraffin by weight. Geology of Green River formation. No oil from drilled wells in this formation.

418—ANON. Oil Industry of France and Alsace. Petroleum World, *16*, 370-74 (1919).
Oil industry in general in France, and includes shale operation. Shale industry quite promising in 1858-1864 until American oil almost extinguished it. Distillation in vertical retorts, 13-16 hectoliters, spent shale furnishing fuel; 50-100 liters of oil recovered per hectoliter of shale. Buxieres shale yielded 28-30% lamp oil, sp. gr. 0.810 to 0.820; 40% heavy oil, sp. gr. 0.870 to 0.925; 29% pitch; loss, 12-20%. Autun shales yielded 35-40% lamp oil of 0.820 sp. gr.; 4% heavy oil, sp. gr. 0.860 to 0.868; 25% green oil, sp. gr. 0.895; 20% pitch; loss, 14%. Location of fields by description and map.

419—ANON. Present Status of Oil Shales. Chem. Met. Eng., *20*, 28-31 (1919).
Besides huge deposits of oil shales in Utah, Colorado, Wyoming and Nevada and small areas all over Rocky Mountains, numerous small deposits of asphaltic sandstones are distributed over western plateau. In spite of processes and many companies devised and organized for getting oil from shales, no oil has been produced. Scottish retort combined with labor saving devices of modern by-product coke oven recommended as the installation for distilling oil shales. Distillates are full of highly unsaturated compounds, containing considerable N_2 and S. Acid treating losses very heavy. Amount of recoverable N_2 small. Asphaltic sandstones have been extracted with solvents such as gasoline, and heavy residuum of about 10° Bé, resembling Mexican and California crude obtained.

421—ANON. Scottish Shale Oil Industry. Chem. Trade J., *64*, 391 (1919).
Scottish shale oil industry had to lower prices on account of American and Mexican petroleum.

Price April, 1919

Motor spirits per gal.	2s. 2-½d.
Burning oil " "	1s. 2d.
Fuel and gas oil per ton	£13
Pale oil per ton	£24 7s. 6d.
Ammonium sulfate per ton	£16 15s.
Paraffin wax per lb.	7-⅝d.
Naphtha per gal.	2s. 2-½d.

422—ANON. Peat Distillation. Sci. Am. Supp., *84*, 341 (1919).
Describes process claimed to be equally applicable to treatment of peat, lignite, and shale. Peat macerated to break up cellular structure which facilitates process of removing moisture. Then formed into briquettes and dried in horizontal chamber above retort until water content reduced to 20-25% by weight. Briquettes kept in constant motion by scraper or conveyor and slowly carried forward through hot gases that are on their way to flue. Retorts consist of iron tubes 24 ft. long and 18 in. in diameter. Screw conveyor passes through the center of tube with ⅜ in. clearance all way around, and driven very slowly so 45-50 minutes required for charge to pass from top to bottom of retort. Heat increases gradually from top to bottom. After apparatus has been in operation for an hour, the permanent gases from the peat are used to supply all heat. Gas introduced in the form of jets impinging against sides of retort, air for combustion being blown in by fans. At 100° C., peat begins to give up moisture, and vapor is drawn off, into condensers where non-condensible gas is deprived of all moisture before going into scrubbers. At hot end of retort (400-450° C.) oils given off are driven into condensers and permanent gases are cooled by passing through scrubbers. In 10-ton unit, 10 H. P. sufficient for driving conveyors, fans, pumps, and macer-

ating and briquetting peat. Yield, 25-30 gals. oil per ton dry peat. Results of distillation of oil: Water, 6%; oil below 100° C., 1.25%; 150-250° C., 27.40%; 250-360° C., 48.30%; residual pitch, 15.70%; loss, 3.50%. Fuel oil and paraffins obtained from fractions distilled at 150-250° and 250-360° C., 18 lbs. $(NH_4)_2SO_4$ per ton peat. Charcoal residue 11.82% volatiles; 79.71% fixed carbon; 8.47% ash. Water distillate from process per ton of peat yields; wood spirit, 2.56 gals.; acetic acid, 19.1 lbs. (as calcium acetate) 23.8 lbs.; $(NH_4)_2SO_4$, 8 lbs.; also 4-10 gals. tar.

423—ANON. Southern California's Burning Canyon. Sci. Am., *120,* 629 (1919).
Fire due to petroleum bearing shales in region.

424—ANON. The Oil Shale Deposits of Great Britain. Petroleum World, *16,* 305 (1919).
Great Britain has ample oil resources in shales if technical difficulties can be solved.

425—BACON, R. F. and HAMOR, W. A. Problems in the Utilization of Fuels. J. Soc. Chem. Ind., *38,* 161T (1919); Sci. Am. Supp., pp. 222 and 254 (1919).
Discusses briefly American oil shales in connection with other fuel problems.

426—BASKERVILLE, C. Value of American Oil Shales. Am. Inst. Mining Met. Eng. Bull., 957-60 (1919).
Oil shale contains kerogen which on destructive distillation yields oil and tarry matter resembling petroleum. Some oils have paraffin base and some asphalt base. In 1860 over fifty companies were successfully distilling oil shale. Advent of well petroleum killed industry. A few companies have operated successfully in France and New Zealand. Economic success of oil shale industry depends upon character and quantities of oil produced, good utilization of by-products, adequate facilities, such as water supply, materials, etc.

427—BOTKIN, C. W. The Composition of Oil Shale and Shale Oil. Quarterly Colo. School Mines, *4,* No. 4, 16-17 (1919).
Résumé of published data and comparison of it with analysis made in Colorado School of Mines.

428—BRANNER, J. C. Outlines of the Geology of Brazil. Bull. Geol. Soc. Am., *30,* 189-338 (1919).
Geologic map of Brazil, detailed stratigraphic geology, outlines of general and economic geology and bibliography. Detailed economic geology of country, including information on coal, lignite, and peat, asphalt, petroleum and oil shale.

429—BUREAU OF MINES. Some Concise Information Concerning Oil Shales. Railroad Red Book, *36,* 317-18 (1919).
No commercial shale operations in U. S. at present. Oil is present in shales in form of organic compounds known as kerogen. Destructive distillation causes decomposition of organic matter into hydrocarbon oils and permanent gases. Describes Scottish methods of distillation.

431—BUREAU OF MINES. Information on Oil Shales. Salt Lake Mining Rev., *21,* No. 3, 25-26 (1919).
(See Abstract 429.)

432—BUREAU OF MINES. Oil Shale, Its possibilities. Chem. Age, *1,* 123-24 (1919).
Scottish industry established in sixties. Industry in France established in fifties. Oil exists as kerogen and not oil. Scottish shale yields 23 gals. oil and 60 lbs. $(NH_4)_2SO_4$ per ton. Ammonia obtained by heating shale to incandescence and then introducing steam. Steam shovel mining at 35¢ per ton, underground mining at $1.15 per ton. Costs 0.7¢ to produce 1 lb. $(NH_4)_2SO_4$ in Scotland.

433—BURROUGHS, E. H. Bibliography of Petroleum and Allied Substances in 1916. Bur. Mines Bull. No. 165 (1919).
Includes bibliography on shales.

434—CHASE, R. L. Oil Shale Industry of Colorado. Min. Sci. Press, *118,* 82 (1919).
Map of Parachute district and photographs of outcrops. Shale 8-20 ft. thick. Must be mined by tunnel.

435—CHEESEBROUGH, R. A. Shale and Fuel Oil. Oildom, *10,* No. 6, 42 (1919).

U. S. Geological Survey shows that 40-50 gals. of oil can be obtained from ton of shale. D. T. Day shows that mining costs will be 60¢ per ton. Products from bbl. of oil: 8 gals. gasoline, 16 gals. kerosene, 16 gals. fuel oil has 160° flash and 35° Bé. Fuel oil could be laid down in New York at 42¢ per bbl. 3½ bbls. equal ton of coal or could compete with coal at $3.70 per ton. Labor saving in firing would be enormous. No doubt in few years public utilities will be using this kind of fuel oil. Public utilities of New York alone would save $6,000 per day by buying this fuel at Utah border.

436—CLARKSON, THOMAS. Facts about the Shale Oil Industry. Oil Gas J., *17*, No. 52, 60 (1919).

Bituminous shales vary considerably in color and appearance. Most Scottish shales jet black but some light gray, sp. gr. 1-2. Organic material insoluble in gasoline. Oil produced only by destructive distillation. Yields: Scottish shale 18 gals. oil; 65 lbs. $(NH_4)_2SO_4$; French, 14 gals. oil, 20 lbs. $(NH_4)_2SO_4$; Canadian, 30 gals. oil, 55 lbs. $(NH_4)_2SO_4$. Scottish oil dark green color, gr. 28.5 Bé., cold test, 89°. French shale oils black color, gr. 21.6 Bé., cold test 70°. Canadian shale oils black color, gr. 26.3 Bé., cold test 40°.

Properties of shale oils shown on accompanying table.*

Refining loss large and large quantities of sulfur make refining difficult. Canadian shales poor in wax.

437—CONDIT, D. DALE. Oil Shales of Western Montana, Southeastern Idaho, and Adjacent Parts of Wyoming and Utah. U. S. Geol. Sur. Bull., 711-B (1919).

Geology of oil shales in district and analyses of various samples. Phosphates in some shales of Montana region noteworthy. Short chapter on technology of shale from papers by Winchester and Bureau of Mines.

438—GILBERT, C. E., and POGUE, J. E. Petroleum, A Resource Interpretation. U. S. Natural History Museum Smithsonian Inst. Bull., No. 102, 49-53, 71-73. Petroleum Times, *2*, 81-82 (1919).

Discussion of oil shales as petroleum resource in connection with other resources of United States. Vast areas of shale in Colorado, Utah, and Wyoming, much yielding 50 gals. oil and 3,000 cu. ft. of gas per ton. Several comparisons between oil shales of Scotland and of Colo. and Utah.

439—GREENE, J. A. Oils from Shale and Peat. A Treatise on British Mineral Oils, 168-176 (1919).

Excluding S and N_2 composition of kerogen is: Carbon, 73.05%; hydrogen, 10.62%; oxygen, 16.33%. Ratio of hydrogen to 100 parts carbon: Bituminous coal, 6.58; grahamite, 10.2; cannel-coal, 10.43; Albertite, 11.02; bitumen from Trinidad asphalt, 12.9; Scottish torbanite, 14.1; Scottish oil shale, kerogen, 14.5; torbanite (N. S. W.), 15.9. Shale subjected to low heat in upper part of retort to recover hydrocarbons, and to high heat in lower part of retort to recover NH_3. Crude shale oil dark brown; gravity 0.85 to 0.96. Sets at 30° C. Maximum yield of oil at approximately 500° C. Crude oil yields on distillation: gases, used as fuel; naphtha, two-thirds olefinic in type. Saturated hydrocarbons contain n-hexane, n-heptane, tri-ethyl-methane, iso-hexane, methylpenta-methylene, and hexamethylene. Benzol in naphtha distills at 60-75° C. and toluol between 95 and 105° C. Scottish shale oil yields: naphtha, 4%; lamp oil, 20%; gas oil, 15%; lubricating oil, 15%; hard wax, 7%; soft wax, 3%; coke, gas, residual, and loss, 40%.

Kimmeridge shale: moisture, 5.02%;

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* Shale Oils Distilled.

	Scottish		French		Canadian	
Naphtha	3%	60°Bé.	3.5%	58°Bé.	5.8%	56°Bé.
Kerosene	24.4	44°	20.5	42°	22	46°
Gas oil	10.5	35°	12.6	32°	17	38°
Lubricating oil	21.4	27°	30.2	22°	14.8	25°
Paraffin wax	15		4		1.6	
Still grease	1		1.7		1.8	
Loss	24.7		27.6		37.	

volatile matter, 41.20%; mineral matter, 44.71%; fixed carbon, 9.07%; sulfur, 5.03%; nitrogen, 1.23%. One ton shale yielded 64.75 gals. crude which contained 30.25 gals. water and 34.50 gals. dry oil. Sulfur in crude oil, 3.74%; sulfur in dry oil, about 7%. Unsuccessful methods of desulfurizing: (1) Treating with lime and caustic alkali in process of retorting; (2) passage of vapors through heated tubes which contain desulfurizing agents; (3) desulfurizing oil by chemical means.

Norfolk shale: Sp. gr. 1.3. Shale yields 1% of oil to ether. Analysis: Smith series; moisture, 9.8%; volatile organic matter, 35.1%; fixed carbon, 15.3%; ash, 39.8%. Analysis of ash: SiO_2, 49.50%; Al_2O_3, 20.20%; Fe_2O_3, 10.27%; CaO, 11.68%; MgO, 1.22%; H_2SO_4, 6.30%; H_3PO_4, 0.83%; sp. gr. of crude oil, 0.942 to 0.960. Sp. gr. naphtha, 0.855. 40 gals. oil per ton shale, 66 lbs. $(NH_4)_2SO_4$, 2500 cu. ft. gas. Sulfur, 6.4%. Oil contained 3 to 4% bases and 3-4% phenols. Blackler estimates in distillate from Norfolk shale oil examined by him there were: sulfur-free saturated hydrocarbons, 20%; olefines and diolefines, 50-60%; sulfur compounds, 20%. Hydrogenation in presence of suitable catalyst may eliminate sulfur.

Shale from the south of France: all fractions of oil on distillation contained acids, phenols, and mercaptans. Cyclopentadiene, indene, and fluorene identified by means of sodium compounds. Unsaturated hydrocarbons removed, and acid wash eliminated bases, after which smell of oil was much improved. Most of purified oil distilled between 140 and 200° C. (360 mm.). Sulfur decreased from 15% to 11.4%. Fraction boiling at 170-180° at 360 mm. on treatment with anhydrous aluminum chloride and acetyl chloride, gave propyl and butyl acetothienones establishing presence of butyl and propyl thiophenes.

Kimmeridge shale from St. Champ: Oil, sp. gr. 0.955; carbon, 77.3%; hydrogen, 9.2%; sulfur, 12.0%; nitrogen, 0.04%; oxygen, 1.14%. Fraction boiling at 80-100° was sulfur free; 100-260° (50% of oil) fraction on sulfonation yielded antiseptic product of therapeutic value.

440—DETEOUF, A. Solvents in the Chemical Industry. Industrie Chimique, *6*, 5-7 and 35-8 (1919).

Deals with solvents from various sources and discusses at length distillation of oil shale in France, dealing both with old French vertical retorts and newer Scottish retorts.

441—GAVIN, M. J., HILL, H. H., and PERDEW, W. E. Notes on the Oil Shale Industry, with particular reference to the Rocky Mountain District. Bur. Mines Misc. Publication (1919).

No commercial shale oil operations in this country. Shales yield from nothing to 90 gals. oil per ton on destructive distillation. Manufacture of shale oil in Scotland adequately described. One company erecting a Pumpherston retort in this country for thorough trial on American shales. Location of plant must be carefully considered with reference to following points: quality and quantity of shale, proximity to shale beds, mining conditions of shale bed, water supply, facilities for disposing of spent shale, transportation facilities for disposing of products, labor supply, labor housing, and market conditions.

To mine, break and deliver shale to retorts will cost from $1.50 to $2.50 per ton. Cost of retorting in Scotland before war was 40¢ per ton and refining cost in 1919 was $1.05 per 42-gal. barrel. Before war, cost of fixing ammonia as $(NH_4)_2SO_4$ was 0.7¢ per pound. Byproducts should be given serious study. Methods given of testing shales for yield. Includes shale oil bibliography.

442—GREENE, J. A. (and CUNNINGHAM-CRAIG, E. H.). Oil Shales. Chapter I of A Treatise on British Mineral Oil. 3-30 (1919).

Kerogen may consist of macerated vegetable matter preserved by combining with salts in solution, spores, and proportion of animal matter, according to D. R. Steuart. Another theory is that absorbent bands of argillaceous shales have become impregnated with inspissated residues of liquid hydrocarbons; oil shale indissolubly connected with free petroleum. Usually oil shale zone lies below coal measures and above zone of free petroleum, although zones often overlap. Kimmeridge shales of Dorsetshire contain more free petroleum than Scottish shales. All good oil shales have low specific gravities (1.6 to 2.2). Low

gravity is not entirely due to hydrocarbon content for inorganic matter is also of low specific gravity as compared with ordinary shales. Both lateral and vertical variation in quality of shale common. Seam frequently becomes richer on anticlinal flexures. Shales under microscope show no typical kerogen globules as does torbanite. Carbonized vegetable matter present in many shales, such as Kimmeridge series of Dorsetshire and Norfolk, several Scottish seams, and some in Colorado and Utah. Other rich shales, such as those of Albert County, New Brunswick, of purely marine origin. Deep yellow color shading into rich brown in very rich shales is characteristic of all oil shales; apparently only fine grained argillaceous material capable of taking this coloring since grains of quartz or calcite stand out clear and white. Dried up oil sand displays the phenomenon, therefore, author concludes, that what is known as oil shale has at one time been impregnated with liquid hydrocarbon. Hydrocarbons of the Green River formation attributed to decomposition of algal growths. Theory does not give due consideration to many ascertained facts in oil shale fields, i.e., that vegetable remains in Green River shales are fully carbonized therefore nothing of nature of petroleum could be evolved from it except by destructive distillation. Something of nature of petroleum might be formed from jetonized vegetable matter in Scottish shales but presence of this jetonized matter shows that such chemical action has not taken place. In thick oil shale series carbonized and jetonized matter are in upper strata. Possible that in lower seams something of this nature has occurred. Theory of animal origin rejected. Famous vein of Albertite has origin in stringers which emerge from bituminous sandstone, still containing a little sticky petroleum. Strata pierced by vein are shale, all of which are fully impregnated with kerogen and therefore are unusually rich oil shales. Numerous instances of like occurrences can be cited. Concludes that kerogen is result of inspissation of liquid hydrocarbons which this peculiarly constituted shale or clay has absorbed. Clays have high colloid content: comparatively rich in alumina and alkali metals, and low specific gravity.

443—HINDS, LUNT, DALRYMPLE, and DUCE. The Oil Shales of Northwestern Colorado. Bull. No. 3, Bur. Mines of Colorado (1919).

No commercial oil shale plants operating in U. S. Scottish and Colo. shales differ; therefore, Scottish process must be modified before it can be used successfully on Colo. shales. Nevada shales differ from those of Colo.; therefore, method which is successfully treating latter may not be adaptable to former. Colo. shales richer in oil and have nearly as much $(NH_4)_2SO_4$ as Scottish but lack of adequate railroad facilities is hampering development. Shale oil industry must grow up gradually in U. S. Yield of oil and $(NH_4)_2SO_4$ determined by Scottish method.

444—HOSKIN, A. J. Winning of Oil from Rocks. Mining Sci. Press, *118*, 701-7 (1919); C. A., *13*, 33 (1919).

American experimentation began in 1916. Oil shales should be called "bituminous shales." Are of sedimentary origin. Were laid down in muddy deposits with organic remains. Vast quantities will yield 42 gals. or more. Property rights have been taken under oil-placer claims. Mining problems varied. Shale must be crushed to varying fineness, depending on retort. Various retorts mentioned. Fuel for retorting furnished by shale, spent shale or permanent gas. Refining methods will approach well-oil methods. Cracking necessary if gasoline in quantity wanted. By-products possible but only few staple products should be made at start.

445—ILLINGSWORTH, S. ROY. Yield of Mineral Oil from certain Low Grade Shales. J. Soc. Chem. Ind., *38*, 355T (1919); C. A., *13*, 3318 (1919).

Shales from old Roundwood collieries, Wakefield. Samples distilled in horizontal iron retort mounted in brickwork, charge weighed 56 lbs. Internal temperature 650-700° C., maintained throughout experiment. Gaseous products put through air coolers and scrubbed in 5 ft. tower packed with coke through which stream of creosote oil flowed. 1 liter sample oil distilled in iron still. Steam introduced after kerosene fraction passed over. Distillation continued until chrysene began to distill. This once-run

oil washed with 25% solution caustic soda; water; conc. sulfuric acid, 5% of weight of oil in amount; water. Between washings oil allowed to stand 2 hrs. before reagent was separated. Oil then fractionated. Naphtha fraction redistilled, portion boiling above 160° C. added to kerosene and redistilled to bulk gravity of 0.810 and flash of 78° F. Redistilled fractions treated with 2% of weight of 92% sulfuric acid, water and dilute caustic soda in above order.

446—JAKOWSKY, J. J., and SIBLEY, F. H. Shale Deposits of the United States Rich in Oil. Oil Gas J., *18,* 58, 60, 62-64 (1919).
General aspects of shale industry in U. S. Scottish methods and retorts.

447—MAGUIRE, DON. Oil Shales of the Great Uinta Basin. Salt Lake Mining Rev., *21,* No. 1, 21-26 (1919).
Interestingly written article of author's personal experience in Uinta Basin and shale country.

448—McCOY, A. W. Notes on Principles of Oil Accumulation. J. Geol., *27,* 252-62 (1919).
Experiments in which oil shale, through tremendous pressure at low temperatures, is said to give tiny oil globules. See also Washburne, Science, *52,* 60 (1920) for criticism of article.

449—MORGAN, P. G. Oil Shales at Waikaia, Southland, New Zealand. J. Sci., *2,* 119-120 (1919).
Waikaia oil shales yield 67.4 gals. oil per ton. Sulfur 2.57%, crude paraffin 35 lbs. per ton.

451—NICOLARDOT, PAUL, and BAURIER, HENRI. Essai des Schistes. Chimie et Ind., *2,* 770-777 (1919).
Method for determining oil content of shales and results of distillation with the apparatus. Apparatus is retort made from shell holding about 700 c.c.; heated by blast and enclosed in well insulated covering. Water vapor introduced when desired and products of distillation carried out through delivery tube to U-shaped condenser. Condensate retained in cavity in bottom of condenser until distillation complete. Gases lead out through absorption tower to gasometer. Temperature measured by pyrometer. Results with this apparatus agree within .3 of 1%. Results with water and dry show from 0.4 to 2.45% more oil obtained using water. Density also higher. Presence of hydrogen did not materially affect distillation.

452—NICOLARDOT, PAUL, and BAURIER, HENRI. Dosage de l'Ammoniaque dan les Produits Aquex de Distillations des Schistes, Lignites et Houilles. Chimie et Ind., *2,* 777-779 (1919).
Method for determining ammonia in presence of pyridine. Ammonia compound treated with hypobromite or hypochloride and evolved nitrogen measured. Apparatus (essentially a nitrometer) and method of manipulation described.

453—PEARSE, A. L. Oil Shale. Mining Sci. Press, *118,* 115-16 (1919).
Notes on mining and treatment of shale, with costs and value of products.

454—PEARSE, ARTHUR L. The Oil Shale Industry. Mining Sci. Press, *119,* 109-10 (1919); C. A., *13,* 2438.
Retort must be adapted to quality and character of shales. Higher temperature is required for recovery of NH_3 than for production of oil. 900° F. or below, best temperature for latter; 900 to 2000° F. for former. Costs of production at time of writing given.

455—PERKIN, J. M. The Production of Oil from Mineral Sources. J. Inst. Petroleum Tech., *5,* 75-93 (1919).
Many products distilled from bituminous substances. Products depend on mode of distillation and material distilled. Even distribution of heat difficult because of poor conductivity of material. Whether high or low temperatures should be employed depends on products desired. High temperature gives:
(A) 12,000 cu. ft. gas instead of 5000.
(B) 20 lbs. $(NH_4)_2SO_4$ instead of 10 lbs.
(C) 11 gals. tar instead of 20 gals.
(D) Tar oil aromatic instead of aliphatic.
(E) Hard non-volatile coke instead of soft coke with 8-10% volatiles.

456—PREVOST, C. A. Commercial Treatment of Oil Shale. Railroad Red Book, *36,* 347-48 (1919).

Disagrees with Dean Winchester in regard to capacity of shale oil plants successful from financial standpoint.

457—PUMPHERSTON OIL COMPANY. Report of Directors. Successful Oil Shale Operation in Scotland. Railroad Red Book, *36,* 354-5, April (1919).

After setting aside liberal amounts for every possible contingency, dividend of 6% on preferred stock and 40% on common stock was declared for year 1918.

458—ROESCHLAUB, H. M. Possibilities of the Oil Shale Industry. Eng. Mining J., *108,* 572-6 (1919); Railroad Red Book, *36,* Dec., 1919.

Review of petroleum situation shows that in 1927 800,000,000 bbls. of oil will be needed. Scottish yield is 25 gals. of oil per ton shale. Each acre of Colorado shale land capable of producing 110,000 bbls. of oil. Comparison of Scottish and American conditions. Expect that cost of recovery will be less in U. S. American shales will produce 2500 to 3000 cu. ft. of gas of approximately 450 B.t.u. per ton. Will require 350,000 to 500,000 B.t.u.'s to retort a ton of shale. Mining not complex problem. Several by-products may be obtained. Flotation oils may be recovered. Precious metals have been reported.

459—SIMPSON, LOUIS. Present Status of Oil Shales. Chem. Met. Eng., *20,* 204 (1919).

Advocates use of retorts that will distill for oil alone. Conditions here and in Scotland different. Scotland has high NH_3 content, whereas we have high oil content. Cannot work oil shales by Scottish practice.

461—SIMPSON, LOUIS. Oil Shales. Chem. Met. Eng., *21,* 176 (1919).

Object of article to show why Scottish methods and experience should not be used. Difference in local conditions, oil content and NH_3 yields. Successful retort should embody (1) continuous feed; (2) continuous removal of spent shale; (3) heat supplied through medium of heated gas; (4) method by which heat can be supplied without excessive retort temperature; (5) all heat possible should be conserved; (6) educed gases to be removed when they are formed; (7) gases to be condensed at constant rate and oils to be condensed into four or more fractions; (8) washers without long stop for repair or cleaning will clear gases of all naphtha.

462—SIMPSON, LOUIS. The Importance of the Retort in the Economic Utilization of Oil Yielding Shales. Bull. Can. Mining Inst., No. 38, 310 (1919).

That Scottish shale retorts worked in Scotland is no reason why they will here. Scottish retorts failed on Australian shales. Principles involved in successful retorting are: When hydrocarbon is heated oil first begins to boil and then to vaporize. Vapors further sufficiently heated will decompose into permanent gas. Amount of such decomposition varies greatly with form of retort used and method of operating. Shales should, therefore, be retorted at temperature as low as practicable. Vapor should be removed as soon as possible; temperature required to drive out oil, 150-750° C. Scottish retorts designed to work on shale with low oil and high N_2. Whole of nitrogen not driven off; shale is free from carbon. 1600 to 2000° F. used. Likely conditions in Canada for several years are: high price for oil, low price for sulfate of ammonia with restricted market; therefore should aim to get oil. World production has nearly doubled since 1914, while consumption is stationary. What is wanted in Canada is simple retort that will recover oil quickly and let ammonia go. Solution of both oil and gas retort is one for oil, another for ammonia; latter to be some form of a gas producer. Del Monte retort in England receives considerable attention. Wallace retort has possibilities but is non-continuous. In Scotland necessary to supplement gases used in retorting with from 65 to 120 tons of coal per thousand tons of shale.

463—SIMPSON, LOUIS. Oil Yielding Shales from the Province of New Brunswick. Bull. Can. Mining Inst., No. 1, 42 (1919).

According to Dr. Ells, belt of oil yielding shale extends from Westmoreland County, on the east, through Albert County to point between Aphaqui and Hampton, Kings County. Shales in Al-

bert County procured by removing overburden at small cost. Shale bed cut by fissures filled with Albertite. This mineral mined at depth of thousand feet in some of the Albert mines. All the shale contains some oil. Open pit mining possible; would simplify matters. Not necessary to use Scottish methods of distillation but should design retorts to suit Canadian conditions of climate, finance, etc. Low price electric power available. Disadvantage of using open pits is high cost of machinery due to import duties; samples of richest shales yield: No. 1, 41 Imperial gals.; No. 2, 42 Imperial gals.; No. 3, 52 Imperial gals.; No. 4, 43 Imperial gals. So-called paper shales, available in immense quantities, gave: No. 5, 32 Imperial gals.; No. 6, 34 Imperial gals.; No. 7, 42 Imperial gals. May not be necessary to obtain N_2 products. In Westmoreland County, at Taylorville, outcrop of shales carrying from 42 to 47 gals. occurs. West of Albert Mines, near Roseville, shales yield 45.52 and 56 gals. while 36 tons of this shale, shipped to Scotland, yielded 40 gals. oil per ton shale. Evidence indicates that quantity and probable yield of shale will equal bastard cannel coals of Nova Scotia. Mining in New Brunswick more difficult than in Pictou County, Nova Scotia. Oil is practically free from sulfur, and close to waterways.

464—SKERRETT, ROBERT G. Oil in the Hillsides. Munsey Mag., Feb., 1919.

Popular discussion of shale oil.

465—SMITH, J. T. Great English Oil Fields. Petroleum World, *16*, 365-68 (1919).

New possibilities of Norfolk shales. High sulfur shales are only those on top. Other seams run as low as 0.5% S. Shale yields 50-60 gals. oil per ton. New retort of 20 tons capacity has been completed. Enormous quantities of shale in Norfolk region.

466—STALMANN, OTTO. The Distillation of Oil Shale and the Refining of the Products. Gas Engine, *21*, 371-4 (1919).

Outlines Stalmann process and reviews requirements for successful distillation of oil shale.

467—STALMANN, OTTO. The Production of Shale Oil. Quart. Colo. School Mines, *14*, No. 4, 28-34 (1919).

Description of Stalmann process contributed to an article by John C. Williams.

468—STALMANN, OTTO. Notes on Oil Shale and its Treatment for the Production of Crude Oil. Railroad Red Book, *36*, 281-89 (1919).

Analysis of Scottish Shale

Water (at 240° F.)	2.67%
Volatile matter	24.31
Fixed carbon	12.50
Ash	60.50

Analysis of non-condensable gases gave 23% CO_2, 4% CO, 13% H_2, 22% CH_4, 1% O_2, 37% N_2. Gas has B.t.u. value of 240.

Analysis of Crude Oil

Naphtha	10%
Burning oil	43%
Lubricating oil	40%
Paraffin wax, lb./t.	15 lbs.

Shales produce 12 to 60 lbs. $(NH_4)_2SO_4$ per ton. Beds are fine grained clay shale, laminated, from 10 in. to 10 ft. thick, interstratified with bands containing less kerogen. High oil yield means low NH_3 yield and vice-versa. In American shales $(NH_4)_2SO_4$ yield appears to be independent of oil yield. Scottish shales contain 20% carbon, 3% hydrogen, 0.7% nitrogen, 1.5% sulfur. Shale mined like coal, broken into 6 in. pieces, and then charged directly into retorts. 200 sq. ft. condensing surface required for each daily ton of oil shale treated. Non-condensable gases pass through absorption towers, where showers of water remove last trace of NH_3, gas then used as fuel.

Western shales differ from Scottish in that their silica content is high and alumina content low. Analysis of Elko, Nevada, shale: Volatile matter, 32.60%; SiO_2, 50.97%; Al_2O_3, 7.40%; Fe_2O_3, 5.50%; CaO, 2.05%; MgO, 1.00%; N_2, 0.298%. This shale produces 50 gals. crude per ton. Use cast iron retort for American shales. Loss of nitrogen is 50% but saving on retort repair more than makes up for nitrogen loss. Great heat necessary to recover all nitrogen

necessitates frequent and costly repairing of retorts.

Stalmann retort consists of cast iron pipe 12 in. diameter, 15 ft. long, built in brick furnace with fireplace. Retort hermetically closed at feed discharge ends. Superheated steam enters near discharge end and leaves near feed end to carry off hydrocarbon and ammonia gases as soon as formed. Holds 500 lbs. Larger retorts may have area of 2½ by 1 ft. (oval). Use 4 retorts in one furnace; requires one superheater. Scottish cooling and condensing system inefficient, Stalmann system better. U. S. Patent 1,225,058 embraces following features that Scottish system lacks: (1) Uniform temperature of cooling surfaces, (2) thorough mixing of particles of vapor, (3) forceful friction caused by impinging vapors to be condensed against cooling surfaces. Time of distillation varies from 4 to 36 hours, average 6 to 12 hours.

469—SMITH, GEO. OTIS, and others. Symposium on Western Oil Shales. Railroad Red Book, *36,* 219-27 (1919). Van H. Manning to Sec. Interior (1919).

Believes shale oil production on a commercial scale possible. George Otis Smith, Director U. S. Geol. Survey, 1918, says shale oil will regulate price of gasoline and assure unlimited supply of that fuel. Indications that shales of northwestern Colorado and northeastern Utah can produce ten times as much oil as has been removed from wells since drilling of first well in 1859.

Chester G. Gilbert and Joseph E. Pogue, Smithsonian Institution, U. S. National Museum Bull., 102, Part VI (1918).

Comparison, Shale of Scotland and Colorado and Utah.

Yield from 1 ton Shale	Scotland	Colorado Utah
Oil, gals.	24	50
$(NH_4)_2SO_4$, lbs.....	34	17-35
Gas, cu. ft.....	2000	3000
Shale residue, lbs...	1600	1500

Russell D. George, Colorado State Geologist, states that oil consumption increased approximately 100,000,000 bbls. between 1914 and 1917. Findings of Geological Survey give no hope of discovery of new oil fields of large area in U. S. In 1917 consumption of petroleum exceeded production 21,000,000 bbls. Probable shortage of 42,000,000 bbls. in 1918. Contrasts Scottish and Colorado-Utah shales: Scottish beds thin, irregular, steeply inclined, deep; Colorado-Utah beds thick, horizontal, high above creek levels. Scottish shales poorer in oil but richer in $(NH_4)_2SO_4$. Sp. gr. best shale 1.84. 1 cu. ft. weighs 114 lbs., 17.54 cu. ft. equals 1 ton shale. 18 cu. ft. used in calculations. Shale carrying 0.55% N_2 produces 30 lbs. recoverable $(NH_4)_2SO_4$ per ton. Costs of plants vary according to size, type, location, extensiveness of chemical laboratories and refining plants. 500-ton plant, suitable for turning out four finished products—gasoline, lubricating oils, paraffin wax, and $(NH_4)_2SO_4$—will cost about $2000 per ton per day capacity. Estimate includes all engineering and legal expenses incident to starting up new enterprise. Primary products of oil shale: Shale oil, water, gas, and spent shale. Character of oil depends on temperature, pressure and presence of steam in retort. If sulfur and nitrogen compounds in shale oil are detrimental, they can, perhaps, be shifted to other products of distillation by properly manipulating treating conditions. Rapid heating of shale causes non-condensable gases to form and lessens yield of oil. Injection of steam into heated shale in retort causes larger percentage of N_2 to be converted into NH_3. Possible to remove gasoline, NH_3, and S from fixed gases, before using it for fuel. Yield of N_2 directly proportional to yield of oil. Average N_2 content of shale yielding more than 15 gals. oil per ton theoretically equal to 50 lbs. $(NH_4)_2SO_4$. Commercially 60% of N_2 can be secured, or 30 lbs. $(NH_4)_2SO_4$ per ton shale. Dyes, high explosives, and rubber substitutes are some possible by-products. Disposal of ash or spent shale is problem. Ash equals 60% or more of original bulk of shale.

470—WALTON, S. A. Another Side of the Shale Oil Industry. Petroleum World, *16,* 212-3 (1919).

Shale residue may, by proper treatment, be used for cement material for roads, and building materials.

472—WHITE, DAVID. The Unmined Supply of Petroleum in the United

States. Automotive Industries, *40,* 361 (1919).
Mentions oil shale as future supply when oil is no longer available from wells.

473—WILLIAMS, JNO. C. The Production of Shale Oil. Quart. Colo. School Mines, *14,* No. 4, 17-40, Oct. (1919).

474—WINCHESTER, DEAN E. Oil Shale and its Development in the U. S. Chemical Age, *1,* 119-23 (1919); Railroad Red Book, *36,* 21-27, Jan. (1919).
Prospects are that within next five years immense industry will develop. Will develop as mining and manufacturing industry. Shale does not contain oil as such but contains partly bitumenized vegetable matter in such state of alteration that addition of heat produces oil. Oil shale heavier than coal; richer seams are black and have waxy lustre.

In the U. S., beds occur in ages from Ordovician to late Eocene. Older shales not so rich. Richest and most extensive deposit belongs to Green River formation (Eocene), Colorado, Wyoming, and Utah. Along outcrop of shale beds in Colorado and Utah are but few places where a bed of oil shale more than 10 ft. thick and capable of yielding at least a barrel of oil per ton cannot be found. Elko, Nevada, shales probably younger than Colorado or Wyoming area and are near railroad. Are comparatively soft and easy to mine and yield oil with high paraffin content. Permian shales in southwestern Montana yield quantity of phosphate. Meager information indicates that these shales are not richer than Green River formation. Black shales of eastern U. S. are Ordovician and Devonian. Oil yield rather low. Cannel coals and cannel shales of same region are more promising source of oil. Monterey shales of Southern California are impregnated with oil to such extent that oil may be extracted commercially.

Mining: probably ordinary coal mining practice, modified to suit conditions. Costs should not be greatly different. Most oil shales are 1000 to 1500 ft. above valleys and aerial tramways necessary to handle it. Meager evidence indicates that shale will not be greatly different underground than at surface. Shale must be crushed or ground as type of retort demands.

Many types of retort being built. A number, of course, will be discarded but result of all will, no doubt, yield successful retort. Differences of character between shales of this country and Scotland indicate that different methods will be used in handling them.

Companies Interested: Bishop Process, 1526 North LaSalle St., Chicago; Bronder Process, Wm. F. Mohr, Clark, Long and Co., 50 E. 42nd St., New York City; Catlin Shale Process Co., Franklin Furnace, N. J.; Chew Process, L. F. Chew, Denver, Colo.; Crane Process, Crane Shale Corp., Elko, Nev.; Day-Reed Process, David T. Day, 713 19th St., N.W., Washington, D. C.; Del Monte Process, C. A. Prevost, Am. Rep., Room 814, Souther Building, Washington, D. C.; Erickson Process, Rainbow Petroleum Products Co., Salt Lake City, Utah; J. H. Galloupe Process, J. H. Galloupe, 1101 19th St., Denver, Colo.; Greene-Laucks Process, F. C. Greene, The Denver Coal By-Products Co., Denver, Colo.; J. B. Jenson Eduction Process, C. B. Stewart, 806 McIntyre Building, Salt Lake City, Utah; Pearse Process, Arthur L. Pearse and Co., 50 E. 42nd St., New York City; Prichard Process, Dr. T. W. Prichard, Chemists Club, New York City; Pumpherston or Scottish Process, Glasgow, Scotland; Scott Process, Detroit Testing Laboratory, 674 Woodward Ave., Detroit, Mich.; Simpson Process, Louis Simpson, 172 O'Connor St., Ottawa, Canada; Stalmann Process, Otto Stalmann, Salt Lake City, Utah, or Petroleum Engineering Co., 217 Dwight Building, Kansas City, Mo.; Wallace Process, Geo. W. Wallace, Wallace Coke, Oil and By-Products Co., East St. Louis, Ill.; Wingett Process, The American Shale Refining Co., 631 First National Bank Building, Denver, Colo.

Primary distillation products: oil, water, gas, and spent shale. Character of oil depends upon method of distilling. Number of valuable by-products have been produced. Bringing shale to high temperature quickly tends to yield permanent gas. Injection of steam tends to yield N_2 in form of NH_3 rather than pyridine compounds as is case when distilled dry. NH_3 content increases with

oil content. Commercially about 60% of N_2 obtained as $(NH_4)_2SO_4$. Ash content about 60%.

At present no satisfactory information regarding mining, delivery, etc. Cost of mining probably about $1.00 per ton. Extensive tramways costing $15,000 to $20,000 must be installed in vicinity of DeBeque. Cost of installing various retort systems varies from $300 to $2500 per ton of shale per day. Cost of plant would probably be half a million dollars or more for treating 1000 tons shale per day.

475—WINCHESTER, DEAN E. J. Franklin Inst., *187*, 689-704 (1919). Believes oil shales of Rocky Mountain district will eventually make up deficit in natural occurring oils. Oil shale is tough thin bedded structure, weathers bluish white. Good oil shale should burn with sooty flame. Oil shale beds generally lie horizontally and sometimes two to three thousand feet above valleys. Green River shales laid down in fresh water and contain abundance of fossils. Oil thought to come from vegetable matter in shales. Green River shales increase in N_2 with richness in oil. Destructive distillation yields oil, gas, water and spent shale. These shales may be expected to yield 30 lbs. $(NH_4)_2SO_4$ per ton. Reports that shales contain gold, silver, lead, etc., in paying quantities apparently without foundation. No shale analyzed contained more than one dollar per ton in precious metals. Several by-products possible but must wait until oil made commercially before they can be developed. In Scotland cost of production of crude oil and NH_3 is $1.85 per ton shale. Successful plant will have to treat 1000 or more tons of shale per day.

476—WOLFF, H. J. Commercial Possibilities of Oil Shales. Eng. Mining J., *108*, 217-19 (1919).
Analysis: 1-3% moisture; 20-50% volatile; 45-80% ash; 0.5-4% asphalt; 2-9% paraffin. Ute Oil Co. of St. Louis erecting a 400-ton plant at Watson, Utah. Wallace Process. American Shale Refining Co. developing on stream 12 miles from DeBeque. 150-ton Wingett retort. Oil Shale Mining Co. developing on Dry Creek, 20 miles from DeBeque; Henderson retort. Mt. Logan Oil Shale and Refining Co. 4 miles from DeBeque. Colorado Carbon Co. 27 miles from DeBeque. Seam 60 ft. thick and 70 gals. per ton.

477—WOOD, H. L. Shale Oil as a Business Proposition. Sci. Am., *120*, 484 (1919).

478—ABRAHAM, HERBERT. Asphalts and Allied Substances. New York, Van Nostrand, 1920, 2nd ed., 608 pp. Cf. Abs. 329, 331, 332.
Several references to oil shale under title of pyrobitumens.

479—ACHESON, EDWARD G. Is Synthetic Petroleum Possible? Chem. Met. Eng., *25*, 268 (1920).
May be possible to produce petroleum synthetically. Suggests U. S. Bureau of Mines should distribute liberal samples of oil shale among chemists of U. S. so that they may develop an interest in and possibly make discoveries of advantage to industry.

481—ALDERSON, VICTOR C. A Directory of Oil Shale Retorts. Col. School of Mines Supplement, *15*, 21, Oct. (1920).
Facts and details of different retorts and processes for extraction. Bibliography of publications on industry by the author.

482—ALDERSON, VICTOR C. Present Status of Oil Shale Industry. Railroad Red Book, *37*, 19-31 (1920).
Résumé of commercial aspect. Comparison of shale and crude oils. Practical development. Future question. Financial aspect.

483—ALDERSON, VICTOR C. The Oil Shale Industry and Its Possibilities. Oil, Paint, Drug Rep., *97*, No. 26, 16; *98*, No. 1, 15 (1920).
Data on deposits of oil shale. Nature and origin of oil shale. Location and leasing of shale land. Estimated costs of distillation and refining plants. Probable future of shale oil industry.

484—ALDERSON, VICTOR C. Oil for Centuries in West. Petroleum Age, *7*, No. 2, 49-51 (1920).
Shales of Colorado alone can keep 100 plants going for 800 years. Costs of mining shale. Oil and gasoline of very good

quality from shales. Scottish and American shales compared.

485—ALDERSON, VICTOR C. Oil-Shale Industry in Scotland and England. Am. Gas. Eng. J., *113,* 255-60 (1920); Colorado School Mines Quarterly, *15,* Oct., 1920; Railroad Red Book, *37,* pp. 891-906, Sept., 1920.
Analyzes methods employed successfully abroad and bases suggestions on these findings for utilization of American shales. In 1919 about 3 million tons of Scottish shale retorted. Average yield 20 gals. oil and 40 lbs. $(NH_4)_2SO_4$ per ton. English shales extensive but practically worthless owing to high percentage of sulfur, 6-8%.

486—ALDERSON, VICTOR C. The Oil-Shale Industry. F. A. Stokes and Co., N. Y. (1920).
A book containing miscellaneous collection of facts, figures and views of oil shale and shale oil industry. Essentially popular in nature. Reviews petroleum situation and points to eventual utilization of oil shales. Geographical location of shale deposits given with history of the shale industry abroad. Chapters on "Retorting and Reduction" and bibliography appended.

487—ALDERSON, VICTOR C. The Shale Oil Industry. Mag. N. Y. Petroleum Exchange, *1,* No. 6, 10-12 (1920).
New developments in British shale oil industry and changes in method of oil extraction. Comparison from analyses between British, Scottish and U. S. shales. In some respects a quite novel way of day wage payment is in force in Scotland. Minimum wage but no maximum. Problem of removal of sulfur from English shales makes them practically worthless, a factor in favor of American shales. Conclusion of characteristics of English and Scottish shales and study of most efficient methods with prediction of three types of retorts to be used in future.

488—ALDERSON, VICTOR C. What to do with Shale Oil. Petroleum Mag., *9,* No. 6, 32 (1920).
Conclusions drawn by author on trip to plants operating abroad. Predictions as to our future retorts.

489—ALDERSON, VICTOR C. Why Shale soon will Vie with Petroleum. Petroleum Mag., No. 3, 96-98 (1920).
Summary of past record of shale. Location of good shales. By-products of shale. Distribution of shale. Figures on beds in different states. Costs, difficulties and advantages. Analogy to other industries once thought pipe dreams.

491—ALDERSON, VICTOR C. The Present Status of the Oil Shale Industry. Colo. School Mines Mag., *10,* No. 2, 19-25 (1920); Chem. Age, New York, *11,* 427 (1920); Petroleum Times, *3,* 275-6 (1920).
Prices crude petroleum and compares with cost of crude shale oil. Approximate cost of producing crude shale oil $1.85 per bbl. Retorting practice outlined. Practical development discussed with name and location of companies operating. Financial aspect and future of industry discussed.

492—ANON. Scottish Oil Shale Possibilities. Chem. Met., *22,* 277 (1920).
It is shown that Scottish shale deposits still contain large reserves of usable shale, these known reserves being four times as much as has been used to date. Origin of oil shale discussed but no new facts presented.

493—ANON. An Oil-Shale Plant. Mining Sci. Press, *120,* 349 (1920).
Discusses trial run of Galloupe retort at plant of Western Oil Shale Co. near Grand Junction, Colo. Capacity 80 tons a day. 50 gals. oil per ton shale. By fractional condensation fraction capable of direct use in automobile was obtained.

494—ANON. The Johns Method of Shale Oil Extraction. Chem. Age, New York, *28,* 313 (1920).
Brief description of process, chief features of which are continuous and practically automatic operation, complete eduction of recoverable hydrocarbons, and use of carbonaceous residue and uncondensable gases as sole source of heat. Ash is recommended as excellent material for brickmaking.

495—ANON. Government Research in Oil Shale Technology. Chem. Age, New York, *28,* 293-4 (1920).

Outlines research work of U. S. Bureau of Mines, in co-operation with State of Colo., at University of Colo., Boulder. Problems and object of research discussed.

496—ANON. Use of Oil Shales. Chem. Eng., New York, *28,* 18 (1920).
Oil shales have great possibilities of development if pushed. Popular review of shale oil situation.

497—ANON. Who Knows about Shale Oil? Chem. Met. Eng., *22,* 386 (1920).
Progress toward a solution of shale oil problems such as proper retort, effect of grinding, rate of heating, refining of crude, etc., disappointingly slow. Probably due to fact that resourceful organization not yet interested.

498—ANON. Report on Test of New Brunswick Oil Shales in the Wallace Retort. Chem. Met., Eng., *22,* 809 (1920).
Abstract of report from Mines Branch of Canadian Department of Mines. Wallace retort consists of cylindrical vertical combustion chamber, containing distilling chamber in form of frustrum of cone, extending throughout height of former. Space occupied by material under distillation thus diminishes gradually from lower to upper end. Special arranged take-off duct provided which removes volatile products as soon as formed, preventing long exposure to heat and consequently formation of unsaturated hydrocarbons. Results given for two typical runs in this type of retort.

499—ANON. Shale Oil Bibliography for 1919. Colo. School Mines Mag., *10,* No. 2, 31-32 (1920).
Bibliography of shale oil by months.

500—ANON. Continuous Operation of Oil Shale Retorts. Shale Review, *2,* 8, p. 9 (1920).
Description of Galloupe retort.

501—ANON. Mining Oil-Shales. Eng. Mining J., *110,* 122 (1920).
Short discussion of mining methods for oil shales. Will resemble coal mining more than metal mining.

502—ANON. Financial Record of Scotch Oil-Shale Companies. Eng. Mining J., *110,* 626-7 (1920).
Scottish shale industry has been amalgamated and united to Anglo-Persian Oil Co., Ltd., an organization in which British Government has large financial interest and dominating control. Report shows Scottish oil-shale companies have not been very great financial success. Report "nil" dividends as late as 1910-1914. Companies found it advisable to mix their product with refined oil bought on market from producers and refiners of crude oil. This practice will probably be continued.

503—ANON. Shale Carbonization Developments. Gas. Jour., London, *169,* No. 2956, 17 (1920).
Outlines development work in Norfolk oil-shales.

504—ANON. Mining for Oil. Literary Digest, *65,* No. 8, 35 (1920).
A review of a paper read before the St. Louis Mining Congress by Victor C. Alderson. Geographic location of oil-shale deposits given as Colorado, Utah, Wyoming, Nevada, Montana and California. Shale abounds in Canada, Scotland, France, South Africa, New South Wales, New Zealand, Tasmania, Brazil, Italy, Spain, Austria, Serbia and Turkey. Probable formation of shales. Mining methods for shale. Room-and-pillar method of coal mining will probably be adopted. Crux of industry is retorting. Several processes for retorting now in course of development.

505—ANON. Oil from Shale. Mag. N. Y. Petroleum Exchange, *1,* No. 1 (1920).
Present oil production and problems for future. Comparison of reserve oil per capita to what it could be per capita considering Colorado alone. Estimate of costs of extraction.

506—ANON. Oil Shale. Mag. N. Y. Petroleum Exchange, *1,* No. 2, 12 (1920).
Interview with Victor C. Alderson on recent progress of oil shale industry. Output of petroleum from wells 2,280,000 bbls. of oil to sq. mile. One 10 ft. seam of shale yielding 1 bbl. to ton will give 15,488,000 bbls. of oil, or seven times average square mile output from wells. 5,500 sq. miles of oil shale in Colo. and Utah will produce 255,000,000,000 bbls.

507—ANON. Oil Shale Station Desired by Bureau of Mines. Mining Congress J., *6*, No. 10, 490-91 (1920).
Request of $175,000 by Bureau of Mines for station. Plans for plant by Dr. Cottrell. Bureau of Mines should investigate problem and not leave it to individuals.

508—ANON. Progress in Construction of Oil Shale Plants. Eng. Mining J., *109*, 812 (1920).
Summary of eight oil shale distillation plants under construction in United States up to 1920.

509—ANON. Expert Holds America's Oil Shortage can be Overcome. Mining Congress J., *6*, 582-6 (1920).
Outlines interview with J. O. Lewis of Bureau of Mines, subject "America's future petroleum supply." Conservation, co-operation and intensified methods of recovery from abandoned and exhausted wells three important factors, along with utilization of new sources of supply. Shales constitute reserve for future supply.

510—ANON. Petroleum Resources of U. S. Insufficient for the Future. Oil, Paint, Drug. Rep., *97*, 13 and 27 (1920).
Interview with Dr. David White, Chief Geologist for U. S. Geological Survey on available supply of petroleum in U. S. and possibilities of solving question of shortage by oil shale and other substitutes.

511—ANON. Extensive Deposits of Tar Sand and Oil Shale. Oil Gas J., *18*, 89 (1920).
Abstract of report by S. C. Ells of the Canadian Dep't of Mines on his survey of tar sand deposits of the Athabaska. Senate of Canada has appointed special committee to investigate commercial possibilities of Canadian oil-shales. Best known Canadian oil shales are New Brunswick deposits near Albert mines.

512—ANON. Shale Oil Extraction by the George Method. Oil Gas J., *19*, No. 7, p. 88 (1920).
Tests of oil shale apparatus invented by R. D. George of University of Colo. Vapors taken off at two points into an air and then to water condenser. Rapid vaporization by using superheated steam and electric blower. Oil yield from two to three times greater by using superheated steam than by dry distillation.

513—ANON. Should Develop Shale Resources. Oil Gas J., *18*, No. 39, 72 (1920).
English writer believes our shortage of crude will soon force us to work our oil shales. Outlines production of crude in foreign fields. Believes American capital should be used in the development of foreign fields.

514—ANON. Oil Shale Deposits in Bulgaria to be Exploited. Oil, Paint, Drug Rep., *97*, No. 26, 12 (1920).
Large deposits of oil shale or bituminous schist in Bulgaria to be developed. Locates five of largest fields in country.

515—ANON. Oil Shale Investigation Needed to Locate Future Oil Reserves. Oil, Paint, Drug Rep., *97*, No. 6, 19 (1920).
Interior Department statement as to necessity for appropriation to carry on research work on oil shales. Asks an appropriation of $70,000 for work. Possibilities of oil shale. Objects of research and purpose of investigation to be carried out by Bureau of Mines.

516—ANON. Oil Shale Entries Made Prior to Leasing Law are All Right. Oil, Paint, Drug Rep., *97*, No. 25, 15, (1920).
Oil shale entries made before the oil leasing law was enacted Feb. 25, 1920, are all right. Interior Dept. announces ruling.

517—ANON. Oil Leasing Act Promises Stimulus to West. Oil Trade J., *11*, No. 3, 13-14 (1920).
Outlines Oil Land Leasing Act (Senate Bill 2775) which provides for limited leases for coal lands, and oil shale lands, for phosphate lands and for sodium lands, reserving to the government certain royalties and rentals.

518—ANON. Shale Oil. Oildom, New York, *11*, No. 10, 41 (1920).
Reviews work of continuous oil extraction plant constructed by Industrial Process Engineering Co., St. Louis. General analyses of oil shales from Colorado,

Nevada, Utah, Wyoming, Kentucky and California.

519—ANON. Oil Shale Days are Here. Petroleum Age, *7*, No. 9, 39-43 (1920).
Names of companies and location of several shale oil reduction plants in Colorado, Wyoming and Nevada. Photographs and locations of shale fields.

520—ANON. Position of Scottish Mineral Oil Industry; Uncertain Future of Shale Mining. Petroleum World, *17*, 81-83 (1920).
Increase in cost of production after armistice, decrease in price of competing products and labor difficulties forced shale operators to refuse laborers agreed wages of coal miners, made economic production of oil from shale impossible. Organized "Scottish Oils, Ltd.," fusion with Anglo-Persian Oil Co. to furnish petroleum to continue operation of refineries and distribution. Price of gasoline, etc., and coal in 1919 opened market for oil in British mercantile marine. Previous market entirely continental. Proposed development of shale oil industry at Norfolk, England. Unfavorable economic factors prevail. Necessary to find new petroleum supply to keep in operation existing Scottish refineries.

521—ANON. Oil Shale has its Problems. Petroleum Age, *7*, No. 12, 123-4 (1920).
Oil shales rather widely distributed throughout U. S. Black shales of the Devonian Age, yielding not over 25 gals. of oil per ton of shale in Virginia, West Virginia, Penna., Tenn., Ky., and Ohio. Very rich shales of Green River (Eocene) Age in Utah and northwestern Colorado. Deposits in Nevada, Montana, Wyoming, and possibly Idaho and Texas. In California very different shale in the Monterey (miocene) formation. Recovery is matter to be worked out on scientific basis. To be commercially successful oil shale operator must produce barrel of crude shale oil at the price for which he can buy at this marketing point a barrel of crude oil containing refinable products of equal value.

522—ANON. Scottish Oils, Limited. Petroleum Age, *17*, 301 (1920).
Report at annual meeting of the shareholders of Scottish Oils, Ltd., a shale oil industry.

523—ANON. Report of English Oilfields, Ltd. Petroleum Times, London, *3*, No. 52, 17-22 (1920); Gas J., London, *149*, No. 2956, p. 35 (1920).
Report at annual meeting of shareholders of English Oilfields, Ltd., by geological expert and chemical adviser. Detailed description of company's holdings and estimated oil content. Chemical nature of shale oil discussed. Gas Journal, London.

524—ANON. Porter Plant Shale Oil is Half Gasoline. Shale Rev., *2*, 3-4 (1920).
Describes Porter process and products obtained. Large percentage of gasoline obtained from shale oil.

525—ANON. Comparative Tests of Lubricating Oils. Shale Rev., *2*, 25 (1920).
Results of experiment at University of Colorado in which a shale lubricant and an oil refined from well petroleum were compared.

526—ANON. The Father of the American Oil Shale Industry. Petroleum Times, *4*, 643 (1920).
Interview with Victor C. Alderson, President Colorado School of Mines. Figures and calculations on amount of oil per square mile per 10 ft. section seam. Cost for mining and treatment with conservative figures on amount of product obtained.

527—ANON. Developments in the Norfolk Oil Shale Fields. Petroleum Times, London, *4*, 405-9 (1920).
Report of English Oilfields, Ltd., on company's properties in Norfolk together with the Board's summary of progress. Report divided into four heads: (1) Company's shale deposits, quantity, quality and method of working; (2) progress regarding shale retorting problem; (3) refining crude oils, and marketable products obtained therefrom; (4) outlook for substantial dividends. On basis of a yield of 30 gals. per dry ton, plus 3 gals. of scrubber spirit, refined products obtained from one dry ton of shale, after working and refining are:

Motor spirit	7	gals.
Kerosene	9.75	"
Lubricating oil	9	"
Bituminous residue	5	" or 50 lbs.

528—ANON. Developing the Norfolk Shale Fields. Petroleum Times, London, *4*, 261 (1920); Petroleum Times, *3*, 213 (1920); and *4*, 239 (1920).
Sketch of Letch shale oil works of English Oilfields, Ltd. Lay-out of works included.

529—ANON. Esthonian Oil Shale. Petroleum World, London, *17*, 137 (1920).
Approximate length of Esthonian field about 100 miles. 1 ton of raw shale (13.7% moisture) yields 232 liters of crude oil. Field not being developed. Some shale used by railroad locomotives.

531—ANON. Scottish Mineral Oil Industry in 1920. Railroad Red Book, *38*, 394-6 (1920).
Reprint from "Glasgow Herald." Yearly report from Scottish Oils, Ltd., 7% dividends declared. Marketable products from oil shale, sulfate of ammonia, paraffin wax and candles, fuel and gas oil and kerosene, burning and power oils. Production given in gallons per year for oil.

532—ANON. Dyes and Paints from Shale Oil. Shale Rev., Denver, *2*, No. 11, 14 (1920).
Crude shale shipped to Denver to be retorted. By-products to be utilized. Aniline fraction of shale oil to be recovered for dyes.

533—ANON. New Oil Industry of S. Africa. S. African Mining Eng. J., *29*, 397-98 (1920).
On possibilities of shale oil in S. America. Estimates of costs, prices and output. Possibilities of industry in S. A. by analogy to what has been done in France and Scotland. Hopes of real wells as in U. S. are anything but hopeful. All working conditions as far as coal, shale, water supply, etc., for mining are ideal.

534—ANON. Transvaal Oil Shales. S. African Mining Eng. J., *29*, 491-92 (1920).
Wakkerstroom Companies awaiting news from London. Map of farms under option. Extension of area by Geluk Co. Activity in Ermelo District. Government apathy criticised.

535—ANON. Augmenting our Oil Supplies. The Street, New York, *3*, 607 (1920).
Development of shale oil industry to augment our present petroleum supply. Popular discussion of shale oil industry. Selection of property in which all factors mentioned will combine to produce lowest possible unit cost is exceedingly difficult and delicate task and requires engineer with keen appreciation of business economics. Successful operation involves proper selection of shale deposit as to yields and location.

536—ANON. What England is Doing in the Development of the Oil Shale Industry. Railroad Red Book, *37*, 563-68, 656-60 (1920).
Address of W. Forbes Leslie of English Oil Fields, Ltd. Quotations of speech taken from Petroleum Times (London). General summary of all England's work on this industry.

537—ANON. Important Ruling in Regard to Oil Shale Titles. Railroad Red Book, *37*, 569 (1920).
Interior Dept. recognized oil shale locations under Placer Mining Law. Recognized legality of oil shale claims under placer law. Permits them to go to patent regardless of oil leasing law recently passed. Letter stating above from 1st Asst. Sect'y of Interior.

538—ANON. Photographic Observations in the Oil Shale Fields of Colorado, Utah, and Nevada. Railroad Red Book, *37*, 826-38 (1920).
Twenty-four photographs of oil shale deposits and developments in Colorado, Utah and Nevada.

539—ANON. Scottish Oil Shale Possibilities. Chem. Met. Eng., *22*, 277-78 (1920).
Discusses origin of oil shales as outlined by H. M. Cadell in paper before Mining Institute of Scotland. Two theories advanced, first that oil shale is result of fine salt deposition under steady conditions of climate and topography, dur-

ing Carboniferous Period; second supposed that shales were not originally petroliferous at all, but merely receptacles of oil that had been injected or "inspissated" into them in some manner from some oil bearing reservoir in vicinity. Estimate of shale resources of Scotland as given in Iron and Coal Trades Review for October 24, 1919.

540—ANON. The Simpson System for Retorting Oil Yielding Shales. Railroad Red Book, *37,* 906 (1920).
Brief description of process. Very general.

541—ASSOCIATED PETROLEUM ENGINEERS. The Relation of the Petroleum Engineer to the Oil-Shale Industry. Petroleum Times, London, *4,* 493-94 (1920).
Outlines shale oil industry under following heads: Occurrence, examination of deposits; economic consideration; cost factors and conclusions.

542—BAIEVSKY, B. M. Baltic Provinces of Russia. Commerce Report. Bur. For. and Dom. Commerce, Washington, Dec. 30 (1920).
Includes (pp. 32-33) description of oil shale deposits of Esthonia. Character and yield of shale and its use for generating gas, for fuel in manufacturing and in locomotives.

543—BAILEY, E. M. The Laboratory Distillation of Oil Shale for the Determination of the Available Yield of Crude Oil and Sulfate of Ammonia. Petroleum Times, *4,* 531-2 (1920).
Description of apparatus used to determine oil content and ammonia in shales. Drawing of apparatus for ammonia determination.

544—BARNETT, E. DEBARRY. Possible Sources of Home Produced Motor Spirit. Chem. Age (London), *3,* 254-5 (1920).
Mentions oil shales as source of motor spirit and discusses inavailability of English shale oils on account of their high percentage of sulfur.

545—BARNWELL, S. E. Eastern Shales form rich Oil Reserve. Shale Rev., *2,* 27 (1920).
On occurrence and properties of Kentucky shales.

546—BASKERVILLE, CHARLES. Utilization of Asphaltic Base Acid Sludge Obtained in Refining Petroleum and Shale Oils. J. Ind. Eng. Chem., *12,* 30-31 (1920).
Explains usual method for destruction of acid sludge and describes new treatment by which this by-product may be converted into useful material possessing commercial value.

547—BEYSCHLAG, R. New and Old Methods of Brown Coal and Shale Coking. 2nd Ed., Berlin, 1920. (Ernst und Sohn.)
German book giving description of European methods of coal and shale retorting.

548—BISHOP, J. A. Scientific Testing of Hydrocarbon Oils. Shale Rev., *2,* 15-16 (1920).
Discusses importance of absolute familiarity with chemistry of hydrocarbons in successful testing and retorting of oil shales.

549—BISHOP, J. A. How Oil is Manufactured in Nature's Laboratory. Railroad Red Book, *37,* 979-85; 1060-66 (1920); Salt Lake Mining Rev., *22,* 27-32, Oct. (1920).
Outlines synthesis of hydrocarbons from the elements and building up of higher members of hydrocarbon series. Describes kerogen as unfinished product of nature. Eocene period responsible for western shales.

551—BISHOP, JAMES A. The Distillation of Shale-Oil. Mining Sci. Press, *120,* 371-5 (1920).
Nature and qualities of compounds obtained from kerogen and chemical nature of products are discussed. Compares "constructive" with destructive distillation.

552—BLACKLER, M. BENNETT. Origin and History of Shale Industry. Shale Rev., Denver, *2,* No. II (1920).
Historical outline of shale industry from seventeenth century to date. Geographical distribution. Nature of oil shale. Origin. Possibilities of shale oil indus-

try. Constitution of hydrocarbons from natural petroleum and of oil produced from oil shales.

553—BOTKIN, C. W. The Unsaturated Compounds of Shale Oil. Shale Rev., *2,* 10 and 16 (1920).
Abstract of paper before the Denver Section of the American Chemical Society, October (1920).

554—BOTKIN, C. W. Analysis of Oil Shale. Colo. School Mines Mag., *10,* 189-193 (1920); Railroad Red Book, *37,* 1051 (1920).
Description of apparatus and methods used in analyzing oil shale. Many practical suggestions. Includes illustration of laboratory apparatus.

555—GEOLOGICAL SURVEY OF GREAT BRITAIN. Summary of Progress of the Geological Survey, 1918. Chem. Met. Eng., *22,* 278 (1920).
Present status of Scottish shale oil industry. Estimate of future supply based on considerations that 3 feet represents minimum workable seam, that mining waste is 20%, and that oil shale cannot be economically mined at depths greater than 300 fathoms (1824 feet).

	Proved and Probable
Estimated shale	601,886,000 tons
Already mined	120,000,000 "
Still available	481,886,000 "

In these figures seams less than 3 feet thick, areas yielding less than 19 gals. per ton, and partially distilled areas with igneous intrusions have been excluded. Annual shale mined 3,000,000 tons plus 600,000 tons waste low grade shales and blaes, total of 3,600,000 tons. At this rate reserve would last 133 years.

556—BURLINGAME, WALTER E. Precious Metal in Oil-Shale. Mining Sci. Press, *120,* 668 (1920).
Open letter to Editor. Found gold to the extent of 13 to 14½ cents per ton of shale. Denounces claim of some that gold exists in oil shale to extent of about $10.00 per ton.

557—CADELL, H. M. Oil Possibilities in Scotland. Trans. Mining Inst. Scotland, *58,* 135-40 (1920).
Discusses probable presence of oil in oil shale field to east and west of Edinburgh and considers possibilities of peat.

558—CAUCHOIS, LOUIS. Bull. Soc. Ind. Rouen, *48,* 301-28 (1920).
Review of merits and properties of various liquid fuels, including shale oils.

559—CHAPMAN, L. W. The Metallurgical Research Dept. of the Utah State School of Mines. Chem. Met. Eng., *22,* 877-81 (1920).
Brief outline of work on oil shale at Utah State School of Mines. Work thus far has been along two lines, (a) study of methods of assaying oil shales for commercial recoverable oil and $(NH_4)_2SO_4$, and (b) investigations of retorting plant together with study of products produced by it from different shales of Rocky Mountain country.

562—Chemical Societies Discuss Liquid Fuels. Chem. Met. Eng., *22,* 296-7 (1920).
Gives résumé of discussion on the possibilities of coal tar, vegetable oils, alcohol and shale oil.

563—CHURCH, E. G. Manufactured Gas Process of Extracting Oil from Shale Results in Maximum Yield of Oil and the By-Product Sulfate of Ammonia. Am. Gas. Eng. J., *112,* No. 7, 117-19 (1920).
Increased oil production by manufactured gas process. Old process in retorting oils in comparison. Oil from shale contains virtually same compounds as ground petroleum. 1 gal. of gasoline from petroleum produces approximately 126,000 heating units, while same quantity of shale oil gasoline will produce 134,000 heating units. Sulfate of ammonia recovery process used in making manufactured gas for heating purposes. Scottish and Colorado shales compared as to nitrogen content. Present condition of petroleum industry.

564—COTTRELL, F. G. Relation of the Bureau of Mines to the Oil Industry. Eng. Mining J., *110,* 678-9 (1920).
Address delivered at convention of Independent Oil Men's Assoc. at Denver, Colorado, September, 1920. Outlines policy of Bureau of Mines in relation to oil-shale development.

565—CRAVEN, HARRISON W. Recent Oil-Shale Literature. Mining Met., No. 165, 31-2 (1920).
Brief bibliography of shale oil literature 1913 to 1920.

566—CROUSE, C. S. The Oil Shales of Estill County, Kentucky. Eng. Mining J., *110,* 24-27 (1920).
Kentucky shales are of Devonian origin and yield about 21 gals. crude oil per ton. Spent shales show no coking properties. Commercial possibilities of Estill shales.

567—CURRAN, JOHN H. Report on Operation of a New Shale Oil Plant. Oil Gas J., *19,* 83 (1920).
Report on operation of Wallace shale oil plant constructed by Industrial Process Engineering Co., St. Louis, Mo. Claimed to be first and only continuous run of any shale oil extraction plant in this country. Outlines advantages of system.

568—DALLAS, WM. J. Commercial Oil Shales. The Street, New York, *3,* 669 (1920).
Popular résumé of oil shale development and its possibilities.

569—DAVIES, J. E. The Outlook for the African Oil Corporation. S. African Mining Eng. J., *29,* 9-10 (1920).
Consulting engineer's report. Results from samples tested. Question of plant and equipment. Map showing properties of company. Valuations, areas and tonnages.

572—DAY, DAVID T. The Oil Famine and the Remedy. American Review of Reviews, *62,* 291-7 (1920).
Thorough investigation, careful experimentation, and judicious expenditure will insure ultimate development of oil shale resources. Mining, retorting, refining and marketing of shale and its products can best be developed by those familiar with similar operations in established fields. Several problems outlined which should be solved before industry is commercial success.

573—DAY, DAVID T. Oil Shale and the Engineer. Eng. Mining J., *110,* 1182-3 (1920); C. A., *15,* 750.
A discussion of (1) economics of the shale oil industry as applied to American development; (2) exploration of oil shale property; (3) the evaluation of oil shale, and (4) the technology of oil shale and shale oil in relation to American deposits. (1) A company must have sufficient funds to carry on extended research and must have an experienced staff of high-grade engineers. (2) Except in preliminary examination the only trustworthy method of complete sampling is core drilling. In Colorado and Utah three drill holes should prove 500 acres. (3) By analyzing samples representing every 5 feet of the core the number of commercial shale beds, thickness, relation to overburden, total tonnage of rich shale, and total recoverable oil from tonnage, may be established. (4) The majority of proposed processes lack sound technical fundamentals and have been an attempt to evolve something radically new rather than to adapt or improve some furnace already proved. The products from shale oil are different from, but not greatly inferior or superior to, those from ordinary petroleum. Shale-oil lubricants, although satisfactory for many purposes, cannot fill the place of steam cylinder oils. The gasoline is unsaturated but better methods of refining are being developed.

574—DEBEQUE, G. ROBERT. Incomplete Retorting of Oil Shales Suggested. Eng. Mining J., *109,* 523 (1920).
Test recently made by Dr. David T. Day using charge of 9 lbs. shale of average grade, yielding 45 gals. per ton by complete retorting. Charge was retorted for 90 minutes, measure of oil being made every 15 minutes during operation. At end of 60 minutes 90.1% of oil has been recovered. Calculation shows saving of incomplete retorting if used in large commercial plant.

575—DEBEQUE, G. ROBERT. DeBeque, The Oil Shale Center. Railroad Red Book, *37,* 106-107 and 825 (1920).
Location of DeBeque. Advantages of location, other industries near. R. R. facilities with electric power from Grand River. Agricultural lands in vicinity. Coal veins, oil wells and gas in close proximity.

576—DEBEQUE, G. ROBERT. Oil Shales of DeBeque, Colorado. Eng. Mining J., *109,* 348-53 (1920).
Present status of development of oil shale industry near DeBeque, Colo. Properties of oil shale. Geology of deposits of this district. Retorting, refining and by-products of shale. Estimate of cost of shale oil eduction plant.

577—DOLCH, M. The Prospects of Utilizing Bituminous Shales and the Results of the Investigation of an Especially Rich Shale. Oesterr. Chem.-Ztg., *25,* 122-5 (1920); J. Soc. Chem. Ind., *39,* 714 A (1920).
Austrian yellow shale of sp. gr. 0.8 resembles earth saturated with well petroleum. Yielded on distillation 31-42% of its weight as oil. 2 grams of this crude oil heated slowly to 300° C. in N_2 gas yielded more than 3 cc. CO_2. Redistilling crude oil yields almost no pitch. N_2 content of shale 0.5 to 2.0%.

578—DOLCH, M. The Investigation of a Bituminous Shale. Petroleum Z., *15,* 881-4 (1920); C. A., *15,* 3740.
Amorphous rather soft stone of dirty yellow to dark brown color. Occurs in layer formation and has sp. gr. 0.748, which confirms conclusion that there are large masses of organic substances in shale. Shale burns with bright flame while unburned residue evolves odor of burned paraffin. Shale can be mined without use of explosives. Analysis of shale gave: moisture 3.4%, ash 21.6%, coke 13% (crude coke 34.6%), volatile substance 62.1% (pure coal 75.1%). Distillation yield 31.5-34.9% oil, N from 0.11 to 22.2%. These results would probably be changed in operation as it is then practically impossible to prevent overheating. Hence yields possible in large-scale manufacture can be better estimated, from distillations carried on by carbonizing large quantities. If overheating occurs, escaping gas is saturated with light hydrocarbons, which can be separated by washing with tar oil. Investigation of composition and calorific value of gas liberated from shale gave following: volatile hydrocarbons 13.1% CO_2 and H_2S 5%, heavy hydrocarbons 15.7%, CO 11.8%, CH_4 21%, H 31.4%, N_2 2.0%. Calorific value of gas 6260 heat units. Yield of oil was 42% of weight of shale and would be higher with better condensation. Combustible in residue was 30%. Tar worked up by F. Fischer's method to determine value of tar especially as regards its paraffin and lubricating oil content gave: neutral oil 27.1%, bases 0.9%, creosote 11.5%, paraffin 9.9%, viscous crude oil 50.0%.

579—CONOVAN, W. and BURTON, C. G. The Distillation of Waikaia Oil Shale. Trans. New Zealand Inst., *52,* 27-9 (1920).
Waikaia shale distilled yielded per long ton: 38 Imperial gallons oil, 8 lbs. $(NH_4)_2SO_4$ and 3250 cu. ft. of gas (freed from CO_2). Oil contained only 6.6% of light oil (naphtha).

580—DODGE, F. E., and RHODES, F. H. Recovery of Pyridine from By-Product Coke Ovens. Chem. Met., *22,* 274 (1920).
Describes method of separation.

581—ELLS, S. C. Notes on the Economic Aspect of a Canadian Oil-Shale Industry. Official J. Can. Inst. Chem., *4,* 181-8 (1920).
Statistics and suggestions relating to the development of oil shale industry in New Brunswick. Review of work done in Scotland. Bibliography.

582—FRANKS, ARTHUR J. Possibilities in Oil Shale Gas. Petroleum Age, *7,* 99-100 (1920); Railroad Red Book, *3,* 543-44 (1920).
Gases from carbonization of oil shale should be a source of alcohols, explosives and other materials. Gases are rich in olefines, ethylene and propylene most prominent. These are source of many valuable organic compounds such as alcohols, ethers and glycols.

583—FRANKS, ARTHUR J. Action of Steam and Gases on Yields of Ammonia from Carbonization of Oil Shales and Coal. Chem. Met. Eng., *23,* 1140-54 (1920).
Discussion of various factors and physiochemical laws affecting the ammonia equilibrium. Outline of synthetic action of steam and hydrogen. Presence of inert gases removes ammonia before decomposition can take place to any extent. Steam has synthetic action at high temperatures.

584—FRANKS, ARTHUR J. The Eventual Retort Plant for the Distillation of Oil Shales. Chem. Met. Eng., *22*, 244 (1920).
A criticism of statement of Simpson that "to obtain the recovery of the maximum yield of nitrogen as ammonia gas, every particle of spent shale should be exposed to a temperature of 1125° C. or 2060° F." Franks gives decomposition temperature of ammonia and cites principle of Le Chatelier.

585—FREEMAN, NAT H. The Solution of Low Temperature Destructive Distillation. Petroleum Times, *3*, No. 72, 542-44 (1920).
Products obtained from destructive distillation vary with heat and temperature used. Low temperatures produce motor spirit, fuel oil, naphtha and lamp oil and finally above the ignition point, phenols, tar, pitch, etc. Dire need of England for such fuels and with present supply of raw material and present state of efficiency of distillation there is sound basis for question "why is something not being done?"

586—FREEMAN, NAT H. Possibilities of Carboniferous Shales. Petroleum Times, *3*, No. 73, 557-58 (1920).
Oil supply of the future. Temperature must be very carefully regulated, to obtain desired products. Multiple retort advantageous over single stage. Use of current of steam or gas to carry over oil and by-products. British Empire controls 2.5% of world's crude oil. Attempt to perfect better distillation operation. Figures on temperatures and costs. Comparisons drawn on costs.

587—FURTH, A. The Fossil Fuels and Their Utilization during 1919. Z. angew. Chem., *33*, 205-8, 217-20 and 223-5 (1920).
A very comprehensive review of the periodical literature and patent files under the following headings: (1) Raw materials: (a) mining, (b) washing and dressing, (c) chemical comparison, (d) fusibility of ash, (e) proximate constituents, (f) utilization of low grade fuels, (g) spontaneous ignition, (h) briquetting, (i) powdered coal combustion, (j) chemical analysis, (k) calorimetry; (2) condensation, handling and purification of gases; (3) measuring, distribution and utilization of gas; (4) calorimetry and analysis of technical gases; (5) production, treatment and utilization of by-products.

588—GAVIN, M. J. Possibilities of Oil Production from Shale. Natl. Petroleum News, *12*, 53 (1920); Bur. of Mines Rep., Ser. No. 2176 (1920).
Paper before the Independent Oil Men's Association, Denver, September, 1920. Shale oil among most promising substitutes for petroleum. Industry of importance to-day only in Scotland. Description of manufacture of shale oil with statistics of yields of oil, NH_3, coke, etc. American oil shale yields more than average Scottish. Scottish practice probably not well adapted to American shales. American industry still in experimental stage.

589—GAVIN, MARTIN J. The Destructive Distillation of Oil Shale. Railroad Red Book, *37*, 442-5 (1920).
Describes "destructive distillation" in popular terms. General discussion of hydrocarbons that make up petroleum. Composition of shale oils. Best retorting produces minimum of hydrocarbons which are objectionable. Factors in distillation which influence product.

591—GAVIN, MARTIN J. Oil Shales and Their Importance. Petroleum Times, London, *4*, 203-4 (1920).
Compares U. S. shales with those of Scotland and France. Estimates amount of work, time and money necessary to develop U. S. shale industry. Figures of our present production and need, and sources of additional oil. National benefit to be derived from such production.

592—GAVIN, MARTIN J. Shale Oil Study shows Progress. Oil, Paint, Drug Rep., *98*, No. 4, 11 (1920).
Colorado and Utah appropriate $10,000 each for oil shale investigation. Probable research procedure to be carried out by Bureau of Mines in conjunction with State of Colorado, at University of Colorado.

593—GAVIN, MARTIN J. Oil Shales and their Importance as Ultimate Resource for Oil. Oil, Paint, Drug Rep., *98*, No. 2, 11 (1920).
Economic importance of oil shales and their ultimate use as supply of petroleum

substitutes. Development of shale oil industry on commercial scale will require years of research, technical study, and great investment of capital.

594—GAVIN, MARTIN J. The Necessity for Research in the Oil Shale Industry. Chem. Met. Eng., *23*, 489-95 (1920).

Discussion of Scottish practice with flow sheet of typical Scottish plant. Desirable lines of investigation outlined. Quality and quantity of oil yields. New and improved practice should be developed from old operation.

595—GAVIN, MARTIN J. Economic Value of Oil Shale. Petroleum Age, *7*, 62-3 (1920).

New fuel source from oil shales. Will yield many products such as oil, ammonia, paraffin. U. S. will always have an oil supply from this source.

596—GAVIN, MARTIN J. Oil-Shales and their Economic Importance. Chem. Met. Eng., *23*, 289-90 (1920); Mining Sci. Press, *121*, 193-4 (1920).

An address. Development of an oil shale industry to scale sufficient to be of economic importance will require much study, time and money. Shale oil industry will work best on large scale production.

597—GAVIN, M. J., and SHARP, L. H. Physical and Chemical Data Relating to Colorado Oil Shale. Oil Gas J., *19*, No. 18, 86-8 (1920); Eng. Mining J., *110*, 579-80 (1920); Bureau of Mines Rep., Serial No. 2152 (1920).

Heat of combustion of DeBeque oil shale 2460 cals. per gram, after retorting, 600. These shales have density 1.92-2.06, specific heat 0.265 from 20° to 90°. Heat conductivity of this shale is 0.00382 at 25-75°. Analysis of shale: Volatile and fixed carbon, 40%; oil per ton, 42.7 gals. Ash: SiO_2, 44.70%; R_2O_3, 25.60%; and CaO, 17.65%; MgO, 5.28%. Above results are shown in tables in comparison with data on other materials.

598—GAVIN, M. J., and SHARP, L. H. Investigation of the Fundamentals of Oil-Shale Retorting. Bureau of Mines, Serial No. 214 (1920); Oil Age, *16*, 25-8, Aug. (1920); Petroleum Age, *7*, 64-5, Aug. (1920); Oil, Paint, Drug Rep., *98*, 11, July 27 (1920); Railroad Red Book, *37*, 729-31 (1920).

Outlines work to be undertaken on oil shale retorting by Bureau of Mines in coöperation with State of Colorado. Plan to furnish definite and impartial information on oil shale retorting.

599—GAVIN, M. J., and SHARP, L. H. Investigation of the Fundamentals of Oil-Shale Retorting. Bur. Mines, Reports of Investigations, Ser. No. 2141, 1920, 4 pp.; C. A., *15*, 309.

Purpose of the investigation is to determine with scientific accuracy effect of various variable factors in retorting oil shale on quality and quantity of products produced, and most favorable conditions for producing highest yield of best products. An experimental retort has been designed and installed, together with necessary auxiliary equipment for controlling process and recovering products. Retort is cast iron, externally heated, horizontal, rotary and cylindrical. Set in firebrick furnace and insulated. Capacity is 75 lbs shale at a charge. Gas is the heating medium. Shale from the DeBeque, Colo., field is to be utilized. It yields on distillation about 42 gals. of oil per ton.

600—GAVIN, M. J., and SHARP, L. H. Data on Colorado Oil Shale. Bur. Mines, Reports of Investigations, Ser. No. 2152, Aug., 1920, 8 pp.; Gas Age, *46*, 219-20 (1920); C. A., *15*, 309.

Large-scale laboratory retorting tests have been made to determine the conditions for producing the highest yield of best quality products from Colo. shales.

601—GEORGE, RUSSELL D. Oil Shale Possibilities. Railroad Red Book, *37*, 643-56 (1920).

Advises use of Scottish retorting methods at least as a basis for work in U. S. Five retorting problems outlined:

(a) To obtain highest yield of oil and other useful products.

(b) To produce oil containing highest percentage of valuable constituents.

(c) To produce easily refined oil.

(d) To secure maximum yield of NH_3

and other useful products without sacrificing oil yield.

(e) To secure highest commercial efficiency.

602—GEORGE, R. D. Problems of the Oil Shale Industry. Chem. Age (N.Y.), *28,* 453-7 (1920); C. A., *15,* 1988.

Conclusions are that fundamental problems of shale oil industry are solved; retorting presents fewer difficulties than does refining; many refining problems, however, will vanish if retorting is done properly. American inventors are "inventing" apparatus and processes abandoned 20 or 30 years ago, and often are not profiting by Scottish experience. Problems of retorting are discussed with reference to: (1) Yield of products, (2) quality of crude oil, (3) yield of NH_3, (4) commercial efficiency. 650-750 lbs. of steam to ton of shale give best results. Advantages of steam in retorting are: (1) Evolution of products at lower temperature, (2) 2 or 3 times yield of $(NH_4)_2SO_4$, (3) higher per cent of light oils in crude, (4) lower per cent unsaturated hydrocarbons, (5) the prevention of coking and clogging, (6) more rapid removal of oil vapors from retort. Experiments in retorting under pressure have proved unsatisfactory. Average N_2 content of Colo. shales is 0.6%, which equals 56 lbs. $(NH_4)_2SO_4$ per ton, of which only about one-half is available by commercial retorting. Lubricating oils from shale oil retain viscosity at much higher temperatures than do oils of similar density and flash point made from petroleum. A well made crude shale oil should yield from 16 to 22% motor gasoline and 40% kerosene distillate; these products contain roughly 60-70% olefins. Shale oil gasoline should be a superior product, if properly refined.

603—GIFFORD, H. J. Manufactured Gas to Supply Heat for the Extraction of Oil from Shale. Am. Gas Eng. J., *112,* 7 and 11 (1920).

Cast iron vertical retort 9 ft. high with circular section about 40 in. diameter. Within retort is perforated cast iron tube closed at top. Material to be distilled introduced at top into space between retort wall and perforated tube. Heated to 1000° F. Gas can escape only through perforations of inner tube. Discontinuous process. 9 lbs. shale gave 135 cc. oil after heating for 15 minutes. After this, results are:

Time, minutes	Oil, cc.
15	135
30	230
45	240
60	80
75	10
90	65

Permanent gas, 11 cu. ft. Weight of residue, 6½ lbs. Oil per ton, 45 gals. 2400 cu. ft. gas per ton. Oil refines 20% gasoline products. 60-80% of kerosene and gas-oil can be converted into gasoline. Manufactured gas process of extracting oil from shale gives maximum yield of oil and by-product $(NH_4)_2SO_4$.

22 billion barrels of oil possibility of process. Estimates of production cost show possibility of shale oil competing with gasoline at its lowest previous level. Almost unlimited possibilities for development. Products obtainable from shales, and their values. How distillation is made. Results of tests.

604—GINET, J. H. The Shale Oil Industry. Mag. N. Y. Petroleum Exchange, *1,* No. 5, 11-13 (1920).

Description of Ginet Process now in use in Colorado shale deposits. Single unit plant of "Ginet Type," costing $40,000, will produce high grade oil at the rate of 70 bbls. per day. Yearly earning capacity of plant estimated.

605—GIRARD, L. E. Oil Shale Locations. Mountain States Mineral Age, p. 10, Aug. (1920).

Reviews requirements for patenting oil shale lands.

606—GRAY, ALEXANDER. Canadian Oil Shale Industry Looming. Can. Mining J., *41,* 926-7 (1920).

Oil shales of New Brunswick to be worked after much preliminary investigation. Preliminary investigations outlined. Estimates on plant production given.

607—GRUBE, G. Commercial Utilization of Oil Shale. Z. angew. Chem., *33,* Part I, 181-2 (1920).

Abstracts of four papers presented in Stuttgart at technical conference dealing

with source of energy in Württemberg. Large deposits of shale in Württemberg yield 6-7% of oil upon distillation. By special process Grube has increased yield to 10-11%. Production of gas from this shale handicapped by large percentage of mineral matter in shale (70%). Use of this residue in making building stone is possible, since its hydraulic properties are good enough to make satisfactory stone. Manufacture of gas for lighting limited to localities near deposit.

608—GRUBE, G. The Technical Utilization of Swabian Slaty Marl (Posidonienschiefer) and its Commercial Significance. Chem. Ind., *43*, 419-24 (1920); C. A., *15*, 2177.
This marl is shale with content of bitumen of 10-15%. Mineral portion clay-limestone having considerable mechanical strength. Technical operations will be directed to using lower portion of deposits (3-3.5 m. thick), which yields 5-7% oil on distillation. Upper portions of deposits (4.5 m. thick) yield 2-4% oil. Reserves of shale in Swabia estimated at 450,000,000 cu. m., which should yield 50,000,000 tons crude oil. Heat of combustion of richer shale 1000 to 1500 cal. per kg. Distillation in iron retorts gives only about 40% of bitumen as crude oil. Low yield due to decomposition of initial oil on walls of retorts, since initial products are very unstable. Vacuum distillation increased yield of oil considerably (from 7% to 8-9%). Crude oil has sp. gr. of 0.95, and contains 3-4% S as organic compound. Distillation gives following fractions: 5% naphtha; 40% burning oil; remainder in large part suitable for making lubricants. Presence of easily oxidizable unsaturated compounds makes it necessary to exclude air during distillation and refining of oil. Only small percentages of aromatic hydrocarbons present. Method of Tausz showed that in fraction to 165° the per cent of unsaturated and S compounds 65-80%. Production of producer gas from shale still an experiment. Residue in retort used to some extent in making cement and building stone. Gas can be made in regular gas retorts but this process in the experimental stage also.

609—GUIDO, COSSETTINI. The Shale Industry of Resiutta. Boll. Chim. Farm., *59*, 245-6 (1920); C. A., *15*, 2544.
Resiutta mine of Mt. Salvotti furnishes oil-bearing shale from which following products are manufactured: for pharmaceutical use, ichthyol, pyridine and quinoline bases; for industrial use, volatile unsaturated hydrocarbons for solvents, turpentine substitutes for varnish, and heavy oils; by-products are NH_3, SO_2, pyrrole and $(NH_4)_2SO_4$.

610—GUISELIN, M. Bull. Soc. Chem. Ind., *1*, 95 (1920).
Plea for establishment of symposium on carbonizing of low grade fuels in France. Urges establishment of large shale oil industry in France, citing United States as example in this respect.

611—HAANEL, B. F. Report on test of New Brunswick oil shales in the Wallace Retort. Mines Branch Summ. Report, Can. Dept. Mines, for 1918. Ottawa (1920), pp. 75-85.
Describes the Wallace Retort (from Canadian patent specifications 189,426) and gives results of tests of shale from Albert Mines, New Brunswick.

612—HAMOR, WM. A. The Commercial Status of American Oil Shales. Mag. N. Y. Petroleum Exchange, *1*, No. 7, 9-12 (1920).
Location of shale deposits. Important fuel reserves of economic importance in oil shale deposits. Much fundamental research needed before industry reaches profitable quantity production stage. Scottish experience valuable in the development of American shales.

613—HAMOR, WM. A. The Problems of the Petroleum Industry. Chem. Met. Eng., *23*, 425-34 (1920).
Discussion of important investigations which should be undertaken in following branches of the industry: production of crude oil; refinery technology; oil and gasoline substitutes; and chemical products from petroleum as raw material. Our present production of petroleum may be augmented by successful production of artificial petroleum (crude shale oil) by destructive distillation of American oil shale. Difficulties met in development of this source of petroleum are outlined.

614—HARTLEY, CARNEY. Development of Oil Shale Methods as now being worked out in Rio Blanco Field. Railroad Red Book, *37,* 101-103 (1920).
Short article dealing mostly with design of retorts. Best retort is continuous type. Discussion of cost of mining, installation, etc.

615—HAWKES, C. J. Fuel Oil in Diesel Engines. Engineering, *110,* 749-52 and 786-8 (1920).
Details of experiments with injection of shale oil fuel of 43 sec. viscosity at 70° F.

616—HILEMAN, G. Inginiera Internacional, Tech. Rev., *8,* 157 (1920).
General discussion of possibilities of oil shale.

617—HOWE, H. E. Shale Oil. Sci. Amer., *122,* No. 3, 66 (1920).
Popular description of shale oil industry.

618—JENSON, J. B. Perfecting Titles to Oil Shale Lands. Salt Lake Mining Rev., *22,* 29-30 (1920).
Explains some of the requirements pertaining to shale land locations.

619—JENSON, J. B. Practical Aspect of Oil Yielding Shale Deposits of the Western Slope, I. Salt Lake Mining, Rev., *22,* No. 17, 23-7 (1920).
Shale deposits of Green River Basin, Uintah Basin and DeBeque and Soldiers' Summit fields in Colorado, Utah and Wyoming, constitute greatest deposit. Popular account of geology of these formations. Yield varies from few gals. to over 100 gals. per ton of shale. Scottish type of retort not adapted to shales that yield more than 35 gals. per ton, owing to trouble from mass carbonization. Jenson suggests the word "petrogen" instead of "kerogen" for hydrocarbon substance from which shale oil is obtained, the word "petro-shale" to distinguish from oil shale in which the oil is free, and the word "shalene" for gasoline derived from shales.

620—JENSON, J. B. Commercial Aspect of the Oil Shale Industry on the Western Slope, II. Salt Lake Mining, Rev., *22,* No. 18, 21-5 (1920); C. A., *15,* 1210.
Deals with title to property, examination, and assaying, water supply, retort and refinery sites, methods of mining and mine equipment, and initial costs of plant.

621—JILLSON, W. L. Oil Shale Overestimated. Oil Gas J., *19,* No. 43, 64 (1920).
Address, annual meeting of Oil Geologists, Tulsa, Okla., March, 1921. Takes exception to view entertained by many petroleum geologists and engineers that shale beds of Colorado, Utah and western states should form larger part of America's oil reserve when petroleum fuels are exhausted. Shale deposits of Kentucky cover 853 miles with average oil or kerogen content of 16 gals. to the ton.

622—JOHNS, GEORGE McD. Destructive Distillation of Bitumens. Combustion, *3,* No. 6, 23-6 (1920).
Description of Johns Process for destructive distillation of oil shale.

623—JOHNSON, ROSWELL H. Outlook for Petroleum Production. Mag. N. Y. Petroleum Exchange, *1,* No. 7, 13 (1920).
Oil shale will be utilized, but its arrival must be delayed on account of experimental stage through which industry must pass, because of low percentage of gasoline in shale oils, because not enough capital can be found to create such a large industry very quickly, and because labor and steel required are now in demand for by-product and gas-making plants.

624—JOHNSTON, ALEXANDER. Gasoline Always. Motor, New York, *34,* No. 5, 35 (1920).
Popular review of shale situation. Shale fields of the West hold inexhaustible supply of fuel-producing oil.

625—JONES, J. B. Is the Shale Industry Profitable? Oil Gas J., *18,* No. 37, 72-6 (1920).
Address before American Mining Congress at St. Louis, Mo., Nov., 1919. Estimated supply of shale. Costs for mining shale and value of oil and by-products from data obtained from oil-shale mined in nine states. Costs of producing a barrel of shale oil com-

pared with cost of producing natural petroleum. Utilization of shales will be successful on large scale operation.

626—KARRICK, L. C., and JAKOWSKY, J. J. Problems in the Production of Oil Shale. Salt Lake Mining Rev., *22*, No. 12, 25-7 (1920); C. A., *15*, 943.
Commercial considerations of refinability and usage of oil makes it desirable to obtain as high a percentage of paraffins as possible. This is accomplished by heating slowly at low temperatures and pressures, and avoiding recondensation of vapors. Theory of shale retorting dealt with, and characteristics of American oil shales given.

627—KEMPER, GRAHAM H. Deposits of Shale in Bulgaria. Eng. Mining J., *109*, 1274 (1920).
Locates most important shale deposits in Bulgaria. Best shales yield 12% of crude oil.

628—KISCHER, F., and SCHNEIDER, W. Comparative Experiments on Pressure Oxidation of Peat, Humus Coals and Sapropelites, Ges. Abhandl. Kennt. Kohle, *5*, 135-59 (1920); C. A., *17*, 2491.
Specimens examined included 3 samples of Velen peat, one brown coal, Rhineland, Niederlausitz and Bohemian coal, lignite, union briquet, lignite, cannel, and Württemberg and Messel oil shale. Quantity of sample corresponding to 350 g. of dried material mixed with 212 g. calcined soda and so much water that, together with moisture of sample, 1600 c.c. of 2.5N solution was obtained. Mixture oxidized for 7 hours at 700° C. by air at 43-45 atmospheres pressure led through at rate of 400 liters per hour. Cannel was most resistant, leaving 60% unattacked. Excepting this and oil shale, all samples contained groups which were readily attacked with formation of CO_2, leaving more resistant residues. Exit gas at first contained 8-10% CO_2, but this fell fairly rapidly to 3% and still lower later, but more slowly. All humus coals and sapropelites yielded acid products and humic and resinous products. Peat was most easily oxidized and left smallest residue unattacked.

629—LEWIS, J. O. Relation of the Bureau of Mines to the Oil Shale Industry. Eng. Mining J., *110*, 628-9 (1920).
Bureau of Mines activity should be devoted to technologic rather than to economic factors. Work should include standardization of testing methods and retorts. Fundamental data of use to industry should be worked out.

630—LEWIS, J. O. Our Future Supplies of Petroleum Products. Oil Trade J., *11*, 96-8, 126 (1920); Oil Gas J., *19*, 74-6 (1920); Mining Congress J., *6*, 582-6 (1920).
Address before Independent Oil Men's Association, Sept., 1920. Possibilities of increasing supply of petroleum by improving production methods, increasing imports, and use of vegetable and other substitutes, such as coal and oil shale.

631—LIDGETT, A. The Oil Shale Industry of Norfolk. Petroleum Times, *3*, 213-6 (1920).
Illustrated description of England's newest shale field.

632—LIDGETT, A. Norfolk's Oil Shale Industry. Petroleum Times, *4*, 209-41 (1920).
Norfolk shales expected to bring in enormous quantities of oil and future of these shales cannot be too highly praised. Process now far from being experimental but is really commercially important. Only shales now being worked are those rich oil-bearing ones near surface and easily worked. Enough further down to be sufficient for exploitation for centuries. New method of mining. Each place is prospected to obtain thickness of beds, etc., and then material open cut or stripped out. Very much more economical and does away with labor. Special retorts designed by works manager. Continuous operation and thus no clinkering. Top feed. Several analyses of Norfolk oil show motor spirit, more than 20%; kerosene, 38%; cylinder oil (high grade), 30%; rest being wax rich residue.

633—LODGE, MATTHEW. New Brunswick Shale Deposits. Oil, Paint, Drug Rep., *98*, No. 20, 15 (1920).
Outlines interview with Lodge on New Brunswick shale deposits. Estimates a deposit in Westmoreland and Albert

Counties of 150 million tons, reaching depth of 1500 ft. Average oil content about 45 gals. per ton. Estimated value of deposit.

634—LOW, A. H. Shale Oil and Methods of Refining. Oil Gas J., *19*, 68-70 (1920).
Describes the Scottish process of retorting and refining and compares it with modern American plants.

635—LOW, A. H. Requirements of a Furnace or Apparatus for the Maximum Production of Oil from Shale. Colo. School Mines Mag., *10*, 25-29 (1920).
Fundamental principles involved in retorting oil shales to produce refinable oil. Retorting, cracking, recovery of ammonia, and production of permanent gas.

636—LOW, A. H. Some Observations Relative to Shale Oils. Quarterly, Colo. School Mines, *15*, No. 2, April (1920).
Flow sheet. Catalyzers and their use in distillation. Conversion of unsaturates to saturates. All the products that can be made from well petroleum can be made from shale oil.

637—LOW, A. H. Shale Oil and Its Refining. Quarterly, Colo. School Mines, *15*, No. 2 (1920).
Oil a manufactured product. Results of destructive distillation. Saturated and unsaturated hydrocarbons. Lack of knowledge concerning kerogen. Different retorts and processes. Proper conditions for distillation. Comparison with Scottish shales. Statements of inventors.

638—LUNT, DALYRYMPLE and DUCE. The Oil Shales of Northwestern Colorado. Bul. No. 8, Bureau of Mines, State of Colorado.
Description of oil shale of this district with general discussion of oil shale situation.

639—MARTIN, A. H. Shale Oil is Sold. Petroleum Age, *7*, No. 5, 49 (1920).
Catlin shale-oil company makes contract to furnish distillate to Elko County for tractors and other machines used on highway construction. Brief bibliography on shale is included.

640—McRAE, HECTOR. The Oil Shale Industry. Northwest Mining Truth, *5*, 23 (1920).
On possibilities of Utah and Colorado shales and Wallace process of shale distillation.

641—McRAE, HECTOR. Oil Shale and Shale Oil. Mining Sci. Press, *121*, 616-17 (1920).
Costs of mining shale in different districts and under different conditions. Cost of mining ranges from 40¢ per ton to $1.25 a ton. Refining loss of oil given by one company as 2% and by another as 3%.

642—MEZGER, ROBERT. Oil Shales of Württemberg and their Utilization in Gas Works. J. Gasbel, *63*, 133-38 (1920).
Geology of oil shales and considerable data of carbonization results. Concludes it is rarely practicable for small gas works to attempt to utilize shale for production of gas. Better to recover the oil as a main product, with gas as by-product.

643—Oil Shale Bibliography for 1919. Railroad Red Book, *37*, 33-36 (1920).
Bibliography. Arrangement by months.

644—Oil Shale in Fushun, China. Petroleum World, *17*, 518 (1920).
Reported that extensive oil shale deposits have been discovered in province of Fushun, China.

645—PARSONS, FLOYD W. Oil from Shale. Saturday Evening Post, *192*, No. 38, 34-37 (1920).
Popular résumé of oil shale situation under title Everybody's Business. Geographically locates oil shale deposits in U. S. Estimates oil content. Quality of gasoline and lubricating oil from shale. Estimated costs for constructing plant and revenue to be derived from treatment of each ton of shale according to Wallace. Oil-shale lands reserved by U. S. Government to supply navy with fuel oil.

646—MABERY, C. F., and WESSON, L. G. The Constitution of the Or-

ganic Nitrogen Bases of California Petroleum. J. Am. Chem. Soc., *42,* 1014 (1920).

These bases consist mainly of alkylated quinolines and iso-quinolines. Details of analytical methods and proofs given.

648—PRITCHARD, THOMAS W. The Whitaker-Pritchard Process of Destructive Distillation. Chem. Met. Eng., *23,* 644-6 (1920).

Problems of destructive distillation. Description of Whitaker-Pritchard retort. Findings from experimental tests.

649—REEVES, JOHN R. Oil Shales of Indiana. Indiana Geol. Surv. Eng. Mining J., *110,* 954-5 (1920); C. A., *15,* 750.

Shales advantageously located and homogeneous in structure. Commercial development expected later on. Results given of dry and steam distillation tests. New Albany shale of Mississippian and Devonian ages covers 500 sq. mi. in Floyd, Clark, Scott, Jefferson, Jennings and Jackson counties. Samples collected in 1919 tested by Woodruff and Day apparatus (U. S. Geol. Survey Bull. 641). Results which follow were taken at random. *Indiana shale distilled with steam:* Gallons oil per ton: 10, 12.75, 18.00, 9.50, 9.50, 16.50, 12.00; cubic feet gas per ton: 997, 912, 1836, 570, 886, 1350, 980; pounds $(NH_4)_2SO_4$: 28.5, 22.2, 20.4, 38.4, 35.5, 22.4, 24.0; per cent fixed C.: 6.25, 8.50, 6.90, 8.00, 4.00, 7.90, 8.30; per cent volatile hydrocarbons: 12.84, 13.14, 22.81, 10.90, 9.50, 18.00, 10.40; per cent ash: 80.91, 78.36, 70.29, 81.10, 86.10, 76.40, 81.30. *Dry distillation yields:* Gallons oil per ton, 12 to 30; gallons ammoniacal liquor per ton, 6 to 16. Shale uniformly soft. Low-temperature burning sufficient. K_2O extracted by H_2O. No caking occurs in retort. Oil yield low, but shale easily worked.

650—Report on Operation of Johns Process for Shale Oil Production. Oil Gas J., *19,* 83 (1920); Oil Age, *16,* 30 (1920).

Industrial Process Engineering Co. report on operations of new shale oil plant. Brief description of a plant employing Johns process and tells its advantages.

651—REQUA, M. L. Saturday Evening Post, Sept. 4, 1920.

Article on petroleum situation which also deals with future of oil shale industry.

652—REQUA, M. L. Conservation. Bull. Am. Petr. Inst. No. 132, p. 54 (1920).

True conservation is not hoarding but the wise use of natural resources; and it implies not merely the preserving in unimpaired efficiency, but also a wise and equitable exhaustion with a maximum efficiency and a minimum waste. Conservation, therefore, demands intensive rather than extensive use; . . . and means the greatest good to the greatest number and that for the longest time.

The growth of the industry may be divided into three periods: the period of pioneer, the period of rapid development and the period of maturity. The oil industry has passed two of the great periods of growth and we are now face to face with the third and last period. At present only 10 to 20% of the oil under ground is being won by the petroleum industry. Burned under boilers fuel oil is at best wastefully consumed. Over any long period of time its future use in this manner is without excuse or justification. Employed in the Diesel type of engine, oil is used at a saving of 75% in comparison with its use as fuel oil in steam generation. It is seriously questioned whether the marine steam engine burning fuel oil is not, today, as a matter of fact, an obsolete piece of machinery.

"I should be remiss in my review if I did not call to your attention the means of conserving petroleum by the development of supplementary resources." As an insurance for continuity we should not neglect, in proper time, to make easy the way for our resource allies. The oil shale industry, the coal refining industry, the power alcohol industry, with their potentialities and their limitations, need close consideration. While they may superficially appear as competitors, they are, however, fundamentally our allies.

653—RIGGS, W. E. Millions of Barrels of Crude Petroleum in Colorado Shales. Motor Age, *38,* No. 7, 7-9 (1920).

Describes shale of the DeBeque, Colorado, district. Method for mining and

retorting shale. Reviews Colorado School of Mines Quarterly which compares well oil and shale oil. Enumerates favorable features in oil shale industry.

654—RUBY, GLEN M. Petroleum Possibilities. Railroad Red Book, *37*, 819-21 (1920).
Geological interpretation of shale beds lying between Uintah Mts. of Utah on the north and line of Denver and Rio Grande R. R. on the south.

655—RUSSELL, WM. C. The Oil Shale Industry. Mag. N. Y. Petroleum Exchange, *1*, No. 4, 14-19 (1920).
Commercial possibilities of oil shale in U. S. Recent development and outlook for production of oil from shale. Department of Interior rulings stated.

656—RUSSELL, WM. C. The Oil Shale Industry in America. The Street, New York, *3*, 504-6 (1920); *3*, 471 (1920); Railroad Red Book, *37*, 822 (1920).
Historical development of oil shale industry in U. S. Description of Colorado shale deposits. Profits realized by Scottish concerns. Future of oil shale.

657—SAUER, GRUBE, BURCHARDT, and SCHMIDT. The Utilization of Oil Shale. Wittwer, Stuttgart, 1920. 31 pp. M. 3.50. (For review see Tonind. Ztg., *44*, 1295 (1920); C. A., *15*, 596.)
Symposium on utilization of Württemberg shales, divided under heads of geology, chemistry, distillation and combustion and utilization of residue. Amount of oil shale available in Württemberg is heat equivalent of 130,000,000 tons of coal. This energy might be utilized by dry distillation, gas making for power purposes, manufacture of illuminating gas, or direct burning of oil shale. Thermal deficiencies of these various procedures. Various ways of disposing of spent shale. Concluded that first successful plant will be one which produces by one process the three products: oil, gas, and building stone.

659—SCHEIBLER, H. Isolation of the Active Sulfur Components of Crude Ichthyol, and Related Shale Oils. Pharm. Monatshefte, *1*, 148 (1920); C. A. *15*, 1374.
An address.

661—SCHEIBLER, H. Purification of Shale Oils (Ichthyols) Rich in Sulfur for Medicinal Purposes. Pharm. Monatshefte *1*, 182 (1920); C. A. *15*, 1374.
Process consists essentially in treatment of crude oil at 170° with soda-lime, then, after distillation, treatment of distillate with Na or $NaNH_2$, whereby evil-smelling and colored constituents eliminated. Resulting bright yellow oil, of faint not unpleasane odor containing C, H and S, b. 100 to 300°. From certain fractions homologs of thiophene isolated, which appear to constitute active S principles of ichthyols.

662—SCHNEIDER, W. Yield of Tar and Bitumen from Esthonian Oil Shale (Kukersite). Ges. Abhandl. Kenntn. Kohle *5*, 69-75 (1920); C. A. *17*, 2189.
Distilled from aluminum retort (Fischer & Schrader) this oil shale gave tar 18.5%, water 3.7%, and residue 71%. In a revolving retort the yield of tar was 16% when distilled with steam and 13.5% without. By extraction with benzene in a Soxhlet apparatus, 0.3% of a viscous oily product was obtained, and under pressure the yield reached 0.7%. Protracted extraction with HCl and HF left a product containing only 3% of ash and (ash-free) C 70.8%, H 7.8%, S 1.8%. Water-free kukersite contains about 47% of bitumen, which is a brown powder of sp. gr. less than 1. It is scarcely soluble in most organic solvents.

663—SCHRAMM, E. F. Notes on the Oil Shales of Southwestern Wyoming. Bull. Am. Assoc. Petroleum Geol., *4*, 195-208 (1920).
Most oil producing shales of Wyoming confined to Green River formation. In southwestern Wyoming formation has maximum thickness of about 1800 ft. Rich shale (50 or 60 or more gals. per ton) will burn in a stove and is used by ranchmen for fuel. Table gives results of distillations of 131 oil shale samples collected from various localities in southwestern Wyoming. Number of favorable conditions must prevail for successful operation of oil shale plant. Shale beds must be rich in oil, containing not less than 35 gals. of oil per ton, must be thick and little covered so that shale can be mined with steam shovel.

Plant must be near railroad and available water supply. Expenditure of large amount of capital necessary for big plants so that oil and by-products can be produced on large scale.

664—SCHULTZ, A. R. Oil Possibilities in the Rock Springs Uplift, Sweetwater Co., Wyoming. U. S. Geol. Survey Bull., No. 702, 107 (1920).
Stratiography and structure of the region and oil bearing rocks described in detail, including exposed oil shale beds.

665—SCHUMANN, P. Substitutes for Coal in Gas Manufacture. J. Gasbel, *63*, 447 (1920).
Results of carbonization tests on soft coal, shale, wood and garbage. None of these materials wholly suitable, due to high content of ash and moisture, and of oxygen, which produces low grade gas. Coke in no case was satisfactory. Gases produced contained large percentage of carbon dioxide.

666—SCOTT, JAMES. Petroleum under the Microscope. Petroleum World, *17*, 300, 346 and 385 (1920).
Bitumen-Kerogen. A study of bitumen. Plant pollen considered as a possible source of bitumen or kerogeneous content.

667—SELWYN-BROWN, ARTHUR. Petroleum from Shale. Sinclair's Magazine, *4*, 31-36 (1920).
Résumé of oil shale industry as developed in Scotland and U. S. Outline of Scottish retorting methods. By-products such as gold, silver, platinum and ichthyol chiefly imaginary. Residue from retorting. Tasmania shale sold for agricultural use at $2.00 per ton . Oil shale developments will be of little commercial interest until economic conditions change and force utilization of auxiliary oil resources.

668—SELWYN-BROWN, ARTHUR. The Shale Deposits. Mag. N. Y. Petroleum Exchange, *1*, No. 3, 15-17 (1920).
Describes located deposits of Albertite, Tasmanite, Torbanite, and oil shales. Scottish distillation methods outlined.

669—SIELAFF, G. J. Elko Shale Plant. Railroad Red Book, *37*, 249 (1920).
Description of plant erected by Southern Pacific Railroad Co. under the supervision of Bureau of Mines.

671—SIMPSON, LOUIS. Further notes on a Canadian Oil Shale Industry. Can. Chem. J., *4*, 239 (1920).
A criticism of certain facts and figures given in article by S. C. Ells, "Notes on the economic aspect of a Canadian oil shale industry," in Can. Chem. J., *4*, 181 (1920), Abs. 581.

672—SIMPSON, LOUIS. Recovery of Nitrogen Contained in Oil Shale. Chem. Met. Eng., *22*, 20 (1920).
Discusses "single purpose" retorting for oil only and "dual purpose" retorting for production of oil and NH_3. Scottish and North American shales compared as to quality, oil content, NH_3 yields, wages and market for products. Comparative costs for retorting in both "single" and "double purpose" retorts under conditions in Scotland and America. Predicts that future of oil shale industry is largely dependent upon construction of "single purpose" retort that can be erected at low cost and which will recover maximum quantity of oil.

673—SIMPSON, LOUIS. The Eventual Retort for the Distillation of Oil Shales. Chem. Met. Eng., *22*, 71-72 (1920).
Suggests that two machines should be used in retorting shale, one in which oil gases are recovered and another for recovery of $(NH_4)_2SO_4$. Horizontal revolving kiln, used in manufacture of Portland cement to burn "mix" into cement clinker ideal for treating shale for recovery of ammonia. With certain shales low in fixed carbon, fuel question enters into the consideration of profitable recovery of by-products. Potash found in some shales.

674—SIMPSON, LOUIS. The Eventual Retort Plant for the Distillation of Oil Shales. Chem. Met. Eng., *22*, 244 (1920).
Answers criticisms of Arthur J. Franks concerning correct temperature to use for maximum production of ammonia from shales (1125° C.).

675—SIMPSON, LOUIS. The Importance of the Retort in the Economic

Utilization of Oil Yielding Shales. Bull. Can. Mining Inst., 309-15, March (1920).
Importance of providing retorts specially adapted to shale to be retorted and to local climatic, industrial, financial, and commercial conditions. Applied particularly to Canadian shales.

676—SIMPSON, LOUIS. Light, Heat and Power from Shale. J. Can. Inst. Chem., *4*, 297 (1920).
Advantages of oil (shale oil) over coal. Canadian shale oils as substitutes for coal. Prevention of development of industry by customs duty and war tax on machinery for mining. Figures comparing efficiency of oil and coal for various purposes. Summary of the good effects that would be produced by shale oil industry. How it would make Canada almost independent for iron and iron products if oil could be used as fuel.

677—SIMPSON, LOUIS. Commercial Retorting of Oil Shales. Chem. Met. Eng., *23*, 789 (1920).
Criticises U. S. Bureau of Mines for recommending Scottish style of retort for retorting American shales. Shale found in Scotland is not the only true oil shale. Any shale that contains "kerogen" is true oil shale. Oil obtained from shale may be chiefly a paraffin or, on the other hand, of an asphalt base and percentage of sulfur may vary from one oil to another. Differences affecting commercial value of oil yielding shale. Comparison as to location and character of Scottish and American shales. Simpson criticises several statements of Martin J. Gavin (Chem. Met. Eng., Aug. 18, 1920, Abs. 594) on expenditures necessary for development of oil shale work. Outline of costs of industry.

678—SIMPSON, LOUIS. The Oil-Shale Industry and the Necessity for Common Sense. Chem. Met. Eng., *23*, 813 (1920).
Detailed criticism of article by Martin J. Gavin, "The Necessity for Research in the Oil-Shale Industry." Gavin recommends the use of Scottish retort and process for American shales. Parallel outline shows what was considered "Standard of Perfection" and results given by the Scottish retort.

679—SKINNER, R. P. The Production of Oils from English Shales. Commerce Report, 1038-39, Dec. 6 (1920).
Quotes report of a company exploiting Norfolk oil shales as to character of shale seams, oil content, and method of treatment.

681—The Outlook for the African Oil Corporation. S. African Mining Eng. J., *29*, 9-10 (1920).
Includes analysis of sample of shale and report on progress of development of the company's properties.

682—STANSFIELD, EDGAR and HAANEL, B. F. Summary Rept. Dept. Mines, No. 542, 27-30 (1920).
Number of analyses of Canadian shales given.

683—STEVENSON, J. J. Interrelation of Fossil Fuels. Proc. Amer. Phil. Soc., *59*, 405-511 (1920); *55*, 21-203 (1916); *56*, 53-151 (1917); and *57*, 1-48 (1918).
Includes description of bituminous shales of the Autun basin, France, and oil shales of Scotland.

684—STEWART, ROBERT. An American Source of Potash and Soil Improvement. Proc. Soc. Promotion Agr. Sci., 1920, 143-52; C. A., *17*, 3562.
Pot experiments with finely ground leucite, alunite, and Illinois shale as sources of K on Illinois peat soils summarized for period 1916 to 1920. With corn as an experimental plant increase over check plots was 126% for leucite and 74% for alunite. With clover increase was 100% for leucite and 800% for ignited alunite. With other crops leucite gave good and alunite variable results. Shale produced increase of 168% in yield of sweet clover, 96% of rape, 146% of corn fodder, and 180% of buckwheat.

686—THOMAS, KIRBY. The Possibilities in American Oil Shales. Commerce and Finance, New York, *9*, 907-8 (1920).
Survey of present status of American oil shale industry and its possibilities. Value of recoverable content and estimated cost of production. Total value for lubricating oil, motor fuel, and sulfate of ammonia estimated at $11.00 for each

ton of shale. Cost of mining and treatment $4.50 per ton of shale, excluding plant depreciation or amortization of fixed capital charges. Government has set aside 45,000 acres for reserve for the navy in the Colorado-Utah field. Should yield 20 billion bbls. of oil.

687—TRAGER, E. A. A Résumé of the Oil Shale Industry with an Outline of Methods of Distillation. Bull. Am. Assoc. Petroleum Geol., *4*, 59-72 (1920).
Annual consumption of gasoline and petroleum. Historical development of shale oil industry in France, England and U. S. from 1694 to date. Four companies now operating in Scotland retorting about 200 tons shale per day. Method given for determination of oil content of a shale.

688—TREBELL, B. H. Shale, The Savior of the Oil Industry. Petroleum Times, London, *4*, 433 (1920).
Consumption of oil in U. S. for past two years given as 60,000,000 bbls. per year. Estimates 7,000,000,000 bbls. of petroleum still in ground. Oil in shale in Colorado alone estimated 20 to 39,000,000,000 bbls.

689—TREVOR, T. G. An Oil Shale Industry for South Africa. S. African J. Ind., *3*, 700-4 (1920).

691—TWILLEY, JAY. Oil Shales in the Somerset Fields. Petroleum Times, London, *4*, 314 (1920).
32 sq. miles of shale in Somerset oil field. Daily output of field would be 200,000 bbls. of oil a day for 500 years.

692—U. S. GEOL. SURVEY. Shale-Oil Bibliography. Bull. 641 F, 191-8 (1920).

693—U. S. GENERAL LAND OFFICE. Oil-Shale Leases. Circular 671-2 (1920).
Outlines procedure for oil shale land leasing.

694—VALERIUS, M. M. Shale Oil Plants are Expensive to Operate. Oil Gas J., *18*, 79 (1920).
Successful oil shale eduction plants must have large capacity and require large investment for construction. Oil obtained very viscous so probably could not be transported by pipe line. Very few experienced shale oil engineers.

695—WAGY, E. W. Engineering Aspect of the Petroleum Industry. Oil Age, *16*, 12 (1920).
From Bureau of Mines monthly report of investigations for April, 1920. Discusses need for technical assistance in petroleum industry and outlines possibilities of the petroleum engineer in following fields: Petroleum production engineering, petroleum construction engineering; refinery engineering, natural gas engineering, and oil shale engineering.

696—WHITE, DAVID. Petroleum Resources Insufficient for the Future. Oil, Paint, Drug. Rep., *97*, No. 5, 13 (1920).
Approximates available petroleum supply at 7,000,000,000 bbls. Equals our needs for about 20 years at present rate of consumption. Most significant feature of prospect, however, is probability that two-thirds of our reserve is still in ground. Advocates development of oil shale on large scale by launching and prosecution of sound shale program. Shale oil most natural, satisfactory and ample substitute for petroleum, and is likely to come into market as production curve of natural oil glides downward beyond peak. Briefly outlines foreign production of shale oils. Outlines shale research problems with estimated costs as given by Mr. Gavin, Bureau of Mines.

697—WILLIAMS, HORACE E. Oil-Shales and Petroleum Prospects in Brazil. Mining Met., No. 165, 22-23 (1920); Oil News, *9*, 36, 38-40, Feb. (1921); Eng. Mining J., *110*, 630-1 (1920).
Brief of paper presented before American Institute of Mining and Metallurgical Engineers, Sept. 21-22, 1920. Describes and locates oil shale deposits in Brazil. Discussion by Ralph Arnold and others, in separate paper.

698—WILLIAMS, JOHN C. The Production of Shale Oil. Petroleum Times, London, *4*, 275 (1920).
Defines distillation and bitumen. Historical development of distillation from 1830. Describes development of Henderson oil shale retort as used in Scotland.

699—WILLIAMS, M. Y. Paleozoic Rocks of Mattagami and Abitibi Rivers. Can. Dept. Mines, Survey Report, Part G, 1919 (Ottawa, 1920).
Detailed geology of region and discusses possibilities of oil accumulation. Describes oil shales occurring along the Abitibi River, giving analyses of two samples.

701—WOOD, H. L. Record of Oil Shale Development in the U. S. Nat. Petroleum News, *12*, 29-33, (Sept., 1920).
Present state of development of oil shale plants in western states. Cost of operation, yield of products and commercial possibilities of industry.

702—WUENSCH, G. ERB. Diamond Drilling the Ideal Method of Sampling Oil Shale Deposits. Colo. School Mines Mag., *10*, 29-30 (1920).
Because of inaccessibility and magnitude of Colorado shale deposits, impossible to sample them thoroughly. Suggests diamond drilling as logical method of sampling. Oil shale bibliography for 1919 included.

703—ADKINSON, H. M. New Method of Analysis of Oil-Shales. Salt Lake Mining Rev., *22*, 25 (1921); Oil Gas J., *19*, 12 (Feb. 4, 1921).
On the advantages of rotary retorting apparatus used in making analytical determinations of oil shale samples.

704—ALDERSON, V. C. The Oil Shale Industry in Scotland. Min. Oil Bull., *7*, 213 (1921); Railroad Red Book, *37*, 891-93, 895, 897-99, 902-5 (Oct., 1920).
Reprint from Colorado School of Mines Quarterly, Oct., 1920. See Abs. 485.

705—ALDERSON, V. C. The Present Status of the Oil Shale Industry. Quarterly Colo. School Mines, *16*, 3-12, April (1921); Shale Rev., *3*, 3 (May, 1921).
Brief review of conditions in Scotland, England, France and other European countries, South America, South Africa, Australia, Canada, and the United States.

706—ALDERSON, V. C. The Oil Shale Industry in 1920. Combustion, New York, *4*, No. 3, 28-32 (1921); Shale Rev., *3*, 3, Feb. (1921); Salt Lake Min. Rev., *22*, Jan. (1921); Oil Gas J., *19*, 72; Amer. Gas J., *114*, 69-71, 79-81 (1921); C. A., *15*, 750.
Résumé of development in oil shale industry for 1920 in Scotland, England, France, other foreign countries, United States. Study from standpoints of legal process, experimental work, chemical investigation, problems of refining, and finance.

707—ALDERSON, V. C. Oil Shale Industry, Selected Bibliography. Quarterly Colo. School Mines, *16*, 27-38, April (1921).
Selected oil shale bibliography.

709—ALDERSON, V. C. Recent World Wide Progress in Oil Shale Development. Circular of Information, Colo. School of Mines, Golden, Colo., Aug., 1921; Pet. Times, *6*, 493 (1921).
Recent development in America cited. Progress noted in Italy, Germany, Spain, Bulgaria, Scandinavia and Esthonia. Importance of shale deposits in Brazil and Argentina and increased activity in South Africa and Australia noted. Canadian oil shale development included. Main problems to be solved and increased worldwide interest in oil shales emphasized.

Present low price of well petroleum temporary and acting as a check on speculation and illegitimate promotion of oil shale. Recent activity in Colorado and Utah described. Bibliography of late articles on oil shale given.

712—AMBROSE, A. W. Research in Petroleum. Bull. Am. Pet. Inst. No. 203, 33-34 (1921).
Outlines some of basic problems to be solved in production of petroleum, increase in recovery of oil from sands and manufacture of motor fuels.

713—AMBROSE, A. W. Possible Substitutes for Gasoline. Cal. Oil World, *13*, 82-3, May (1921).
Discussion of possibilities of alcohol and shale oil as substitutes for gasoline.

714—ANON. California Oil Shale may be Utilized Soon. Cal. Oil World, *13*, 2, April (1921).
Describes electric oil extracting process, invented by E. L. Anderson to be used for distillation of California shales.

715—ANON. Progress in the American Oil Shale Industry. Railroad Red Book, *38*, 11-25 (1921).
Progress in American shale industry outlined under mining, transportation, crushing, retorting. Names and describes 41 retorts and processes for distillation of oil from oil shales. 13 photographs of shale oil plants and developments.

716—ANON. Utilization of Oil Shales. Can. Mining J., *42*, 395-6 (1921).
Editorial on necessity for shale development in localities where coal and oil are scarce.

717—ANON. Summary of the Commercial Development of Chemical Engineering in Shale Oil Recovery. Chem. Age, *29*, 30-31 (1921).
Summary of developments in shale oil recovery under following heads: Name of process, owner, type, material of construction, method of advancing shale through retort, throughput dimensions, feed, discharge, size of shale treated, fuel, temperature required, withdrawal of gas and oil vapors, steam used, stage of development and special features.

718—ANON. Experimental Shale Oil Retorting Plant. Chem. Met. Eng., *24*, 312 (1921).
Description of Johns eduction process for oil shales. Experimental 15 ton plant. Cross section of retort. Flow sheet.

719—ANON. Notes on French Industries. Chem. Met. Eng., *24*, 462 (1921).
One oil shale plant of importance in France. Produces about 2½ million gals. of oil per year. Physical properties of oil. Geographical location of French oil shale.

721—ANON. Oil Shale Deposits in Germany. Eng. Mining J., *3*, 713-4 (1921).
Describes recent development of shale deposits brought about by shortage of oil in Germany.

722—ANON. Oil Shale Investigations. Eng. Mining J., *3*, 914, May (1921).
Quotes report made by Secretary of Interior to House Committee on Mines and Mining outlining needs of oil shale research as conducted by Bureau of Mines.

723—ANON. English Oilfield, Ltd., Meeting. Oil, Paint, Drug Rep., *99*, No. 5, 18 (1921).
Minutes of meeting of stockholders of English Oilfields, Ltd. Retorting of shales discussed. Financial position of company outlined.

724—ANON. Bureau of Mines Issues Report on Manufacture of Shale Oil. Oil, Paint, Drug Rep., *99*, No. 8, p. 9 (1921).
Digest of paper issued by Bureau of Mines on experimental work of M. J. Gavin and L. H. Sharp. Main items of investment, expense and profit, based on large scale operation.

725—ANON. The Freeman Multiple Retort and Esthonian Shales. Petroleum Times, *5*, 432, April (1921).
Results of tests of sample of Esthonian shale using Freeman retort. For tests on Norfolk and Kimmeridge shales in same retort, see Petroleum Times, *5*, 416-17 (1921). See Abs. 736.

726—ANON. New South Wales Oil Shale. Petroleum Times, *18*, 286 (1921).
Oil shale mined in New South Wales for 1920 was 21,004 tons, valued at 46,082 pounds. New Shale field covering an area of about 6,000 acres found in the Goulburn River district.

727—ANON. Australia and Oil Fuel Supplies. Petroleum World, *18*, 146 (1921).
Review of fuel oil situation in Australia. Could supply demand through (a) power alcohol, (b) distillation of coal, (c) production of shale oils, or (d) discovery of local oil fields.

728—ANON. Progress in the American Oil Shale Industry. Railroad Red Book, *38*, 11-21 (1921).
List of the more important processes for shale distillation and brief description of 15 experimental plants in United States.

729—ANON. Oil Shale Bibliography for 1920. Railroad Red Book, *38*, 30-38 (1921).
Bibliography. Arrangement by months.

731—ANON. Past Year in the Oil Shale Industry. Shale Rev., *3*, (Feb., 1921).

Activity in Canada. Yields for Abbitibi shale. Yields of different U. S. shales. Figures on depth of veins, etc. Description of many of the U. S. shales including Ky., Utah, Colo., and Nev.

732—ANON. Bituminous Shales of Esthonia. Shale Rev., *3,* 5, May (1921).
Chemical composition and occurrence of bituminous shale (kukersit) of Esthonia.

733—ANON. African Oils. S. African Mining Eng. J., *30,* 618 (1921).
Report of first annual meeting of the African Oil Corp., Ltd., including report on results of tests in Scotland of company's shale.

734—ANON. Oil Shale. Railroad Red Book, *38,* 399 (1921). Reprint from "The Street," New York, Jan. 24, 1921.
Several articles on oil shale written in popular terms.

735—ANON. A New South African Industry. S. African Mining Eng. J., *31,* 883 (1921).
On the possibilities of oil shale of the Wakkerstroom district.

736—ANON. The Freeman Multiple Retort and Norfolk and Kimmeridge shales. Petroleum Times, *5,* 416-7 (1921); C. A., *15,* 2179. Cf. Abs. 725.
These results obtained by low-temperature carbonization in single-chamber retort under agitation. Temperature of chamber regulated by precision automatic temperature control. Oils obtained in both cases are not emulsions nor do they carry H_2O, tars, waxes, or impurities which render the secondary refining difficult matter. Norfolk shale contained 41% total volatile matter, 18% fixed C, and 41% ash. Yields per ton were: total H_2O 13.55%, oil 17.95%, residue 60.71%, gas 7.42% (3500 cu. ft.), loss 0.37%. Sp. gr. of oil 0.973, and yield 41.3 gals. per ton of raw shale or 47.79 gals. per ton of dry shale. Maximum point reached at which distillation of oil ceased 360°. Kimmeridge shale contained 52.3% total volatiles, 16.5% fixed C, and 31.2% ash. Yields per ton were: total H_2O 15.47%, oil 20.75%, residue 53.97%, gas 5.8% (2600 cu. ft.), loss 4.01%. Sp. gr. of oil was 0.973. There was produced 47.76 gals. per ton of raw shale or 56.5 gals. per ton of dry shale. Oil was brownish and apparently high in low boiling fractions. Economical maximum temperature 370° C.

737—ANON. Bituminous Shale (Kukersit) of Esthonia. Shale Rev., *8,* No. 4, 5 (1921); C. A. *15,* 2544.
Deposit extends from Baltic Port to Narva, with average thickness of 1.75 m., and sp. gr. of 1.3. Analysis is: organic material 55.5%, SiO_2 13.6%, Fe_2O_3 2.3%, $CaCO_3$ 17.0%, Na_2O and K_2O 0.2%, water 1.2%. Organic material consists of C 70.52%, H 7.2%, N 0.30% and O 21.98%. Upon distillation shale yields oil and tar 29.07%, gases 21.33%, coke 7.64%, ash 40.15%, H_2O 1.83%. Raw shale has fuel value of 4200-5500 cal. Fractional distillation of crude oil yields gasoline 20%, lighting oil 20%, lubricating oil 20%, tar or pitch 40%. Shale at present being used for (1) distillation to obtain oils, (2) in gas works for production of gas, (3) mixed with pulverized coal for cement burning, (4) for steam-raising purposes in locomotives and ships, and (5) for domestic fuel use.

738—ANON. Shale Oil in Sweden as a By-product of Lime Manufacture. Genie civil *79,* 21 (1921); C. A. *16,* 1009.
In Sweden, lime burned in heaps made of alternate layers of oil-shale and limestone. One ton of shale, capable of yielding 45 kg. of oil if distilled, now used in burning 10 hectoliters of CaO. New kiln designed by S. V. Bergh and K. E. Larsen expected to recover oil and also 30 kg. of S, while burning same amount of CaO with one ton of shale. Even when shale is distilled directly by second process of same inventors, it is claimed that oil can be made at half of its present market price. Presumably gas from shale distillation is source of heat for both processes.

739—ANON. Shale Gasoline versus Petroleum Gasoline. Railroad Red Book, *38,* 868-9 (1921); C. A. *16,* 641.
Shale gasoline obtained from crude oil and with no refining was compared with gasoline as an engine fuel. Comparative tests on same car with same engine adjustments showed shale gasoline to give consistently greater mileage per gallon than ordinary gasoline. The re-

sults were 19.8 and 22.8 miles per gal. of petroleum gasoline and shale gasoline, respectively.

741—ANON. Oil Shale Development in South Africa. Petroleum Times, *6*, 844 (1921).
Transvaal Coal & Oil Shale Corporation has been formed to develop rich torbanite and oil shale deposits of Ermelo district. Yield will be about 70 gals. per ton. 50 ton capacity plant costs about 3500 pounds for installation. Even at low prices for crude oil, exceptional profits are predicted.

742—ARNOLD, RALPH. Oil-Shales and Petroleum Prospects in Brazil. Separate No. 1038, Am. Inst. Mining Met. Eng., 49-51 (1921).
Discussion of paper by H. E. Williams presented at St. Louis meeting September, 1920. Discusses oil shale prospects in Brazil.

743—ASHLEY, GEO. H. Mineral Resources of Pennsylvania. Proc. Eng. Soc. Western Penna., *37*, 1-17 (1921).
Includes discussion of possibility of producing oil from shale.

744—BAILEY, E. M. Shale Oil Data. Oil & Gas J., *20*, 82-3 (1921); C. A. *16*, 159.
Laboratory methods outlined for determination of yield of crude oil and of $(NH_4)_2SO_4$ from shale. U. S. cannot long continue to depend on domestic petroleum production to completely supply demand for petroleum products; sooner or later our oil shales will have to be used to supply deficit. Oil shale industry large-scale-low-grade raw materials manufacturing enterprise.

745—BARNWELL, S. E. Large Deposits of Oil Shale in Kentucky. Shale Rev., *3*, 3, April (1921).
Describes Kentucky shales and discusses their commercial value.

746—JENSON, J. B. Colorado-Utah Petro-Shales. Petroleum Times, *6*, 489-90 (1921); C. A. *16*, 159.
Increase in yield of oil from shale expected. Thus, one paper shale yielded 8¼ gallons oil while by penetrating ledge for 30 ft., yield of 40.5 gallons obtained from massive shale. "Destructo-constructive" distillation of shales converts petrogen of shale into petroleum.

747—JENSON, J. B. The Colorado-Utah Petro-Shales. Petroleum Times, *6*, 469-70 (1921); C. A., *15*, 3904.
Jenson proposes use of following terms in place of expressions now in use: petrogen for material which through destructo-constructive distillation produces petroleums; petro-shales shale still in primary unaltered conditions containing petrogen but not petroleum; oil shales originally petro-shales which through later earth heat have given up their petrogen and then through absorption have taken up resultant petroleum; shalene is term used to distinguish product from shales which corresponds to gasoline fraction. Petro-shales spoken of as massive and paper shales. Latter consists of much thinner beddings or measures than massive. As a rule massive variety slightly higher grade than paper, although when ledge is penetrated beyond weathering, paper shale becomes solid and oil yield usually increases.

748—BISHOP, J. A. Petroleum an Industrial Autocrat. Mag. N. Y. Petroleum Exchange, *2*, 11 (1921). (See Abs. 749.)

749—BISHOP, J. A. Chemical Sidelights on the Petroleum and Shale Oil Industries. Mineral Age, *5*, 9 (1921); Mag. N. Y. Petroleum Exchange, *2*, 11, Jan. (1921).
Necessity for improvement in methods of refining petroleum and further study of application of these methods to shale oil industry.

751—BLACKLER, M. B. Shale Retorting and Refining Problems. Shale Rev., *2*, 3 (1921).
Outlines retorting and refining problems of shale industry.

752—BOSTAPH, H. P. Oil Production from Shale and Coal. Oil Gas J., *19*, 64 (1921).
Discusses important points in design, construction and operation of shale retorts.

753—BOTHWELL, LAWRENCE. Oil Shale Activities. Am. Gas J., *114*, 336 and 346 (1921).

Review of recent progress toward solution of commercial retorting of shale. Includes description of Brown process.

754—BOTHWELL, LAWRENCE. Oil Shale Land Titles. Mountain State Mineral Age, *5,* 10, Jan. (1921).
Discusses questions of title to oil shale claims and assessment work thereon.

755—BOTKIN, C. W. A Study of the Saturated and Unsaturated Compounds of Shale Oil. Quarterly, Colo. School Mines, *16,* 16-26, Apr. (1921); Railroad Red Book, *38,* 603, May (1921); Chem. Met. Eng., *24,* 876.
Results of study of oil shale hydrocarbons to determine extent of their saturation, cause of unsaturates, distribution of saturates, effect of cracking on saturation, and some properties of the unsaturated substances.

756—BREUER, P. K. The Occurrence of German Oil Shales. Brennstoff Chem., *2,* 106-7 (1921); C. A., *15,* 2352.
Review of distribution and bitumen content of workable deposits of oil shale in Germany.

757—BUREAU OF FOREIGN AND DOMESTIC COMMERCE. Oil Shale in Bulgaria. Commerce Rept., 1020-21, May 19 (1921); Oil, Paint, Drug Rep., *99,* 26, May (1921).
Review of article by V. Kantcheff in "Near East", Apr. 28, 1921. Location of deposits, analysis of shale, and discussion of future prospects in this country.

758—CADELL, H. M. Searching for Oil Shales in Scotland. Petroleum Times, *6,* 850 (1921); C. A., *16,* 1500.
Results of series of borings in Blackness district, on south shore of Firth of Forth, described.

759—CHADWICK, G. H. Devonian Black Shales of Western New York. Bull. Geol. Soc. Am., *32,* 91 (1921).
Study of possibly important oil shales of New York State.

761—CLARKSON, WM. The Possibilities of Oil Discovery on the Mainland of Australia. Petroleum Times, *5,* 309 (1921).
Discussion of possibilities of Australian oil shale.

762—COKE, P. S. The Oil Shale Industry. Railroad Red Book, *38,* 391-4 (1921).
Production and consumption of petroleum in U. S. Estimated cost of producing shale oil.

763—COPPADORO, ANGELO. Bituminous Schists of the Non Valley in Trentino, Giorn. chim. ind. applicata, *3,* 3-9 (1921); C. A., *15,* 2544.
These shales very rich and extensive. They belong to same geological stratum as those of Seefield in Tyrol. On dry distillation, schists yield an oil rich in S, which contains pyridine bases and non-saturated compounds possessing strong antiseptic powers. Yield in oil 15% on average. Ammoniacal liquors formed containing 5-10 g. NH_3 per liter. Combustible gases produced amounting to about 6.5 cu. m. per cwt. shale.

764—CROOK, THOMAS. Economic Mineralogy. New York: Longmans, Green and Co. (1921); 492 pp.
Contains section on petroleum and allied products (ozokerite, oil shales and asphalts), giving their occurrence, distribution and properties.

765—CURRAN, J. H. Oil Shale Situation. Oil Age, *17,* 21, Mar. (1921).
Discusses causes of failure of Scottish method of retorting when applied to American shales, and requirements for successful plant.

766—DAY, D. T. Principles and Methods of Oil Shale Distillation. Bull. No. 3 of The Day Co., San Francisco, 23 pp. (1921).
Discusses the factors governing efficiency, economy, and oil recovery of shale retort when oil is main product desired. Describes Day-Heller retort, outlining its advantages.

767—DAY, D. T. Principles and Methods of Oil Shale Distillation. Mining Sci. Press, *123,* 257-63 (1921); C. A., *16,* 1009.
Description included of ideal retort.

768—DAY, D. T. The Quantitative Analysis of Oil-shale and Shale-oil. Bull. No. 2 of The Day Co.; C. A., *16,* 1009.

769—DOBROKHOTOV, N. N. The Combustion of Bituminous Shales in Gas Producers. Industrie russe Petrole schists, No. 5-8, 259-69 (1921); Rev. Metal., *19,* 532-3 (1922); C. A., *17,* 626.

Essential to obtain gas containing as little tar as possible, either by using producer with two combustion zones, or by intensifying gasification to decrease time during which fuel is in producer. Latter preferable with bituminous shales. In producer with dry blast suitable time would be 3-4 hours. As ash is high in CaO and in Al_2O_3 (especially in Baltic provinces), it acts like a hydraulic lime, so that water seals cannot be used. Heat balance given and description of proposed form of producer. If cost per calorie of shale is less than that of another fuel, use of shale is advantageous, disadvantage due to excess of ash being offset by possibility of using latter in place of hydraulic lime.

771—DuTOIT, A. L. Oil Shale in South Africa. S. African J. Ind., *1921,* 346; Bull. Imp. Inst., *19,* 1329-34 (1921); C. A., *16,* 1661.

Oil shale of Natal really variety of coal in some respects approaching cannel, but black, glossy and somewhat laminated. Sample gave on analysis: 0.7% moisture, 3.4% volatile matter, 39.75% fixed C., 25.25% ash. Yield of crude oil varied from 12 to 28 gals. per ton.

772—ELLIOTT, R. D. Oil Possibilities of Northwestern Washington. Mining Oil Bull., *7,* 271 (1921).

Brief description of conditions on western slope of Olympic Peninsula. Shales of Tertiary age and contain foraminifera and diatomaceous remains.

773—ELLIS, CARLETON and MEIGS, JOSEPH V. Gasoline and Other Motor Fuels. D. Van Nostrand Co., N. Y., 567-88 (1921).

Shale as a source of motor fuel. Nature of bituminous shale. Kerogen. Distillation of shale. Steam and dry distillation. Yield of various fractions from shale oil. Methods of mining and milling, with costs. Cost estimates for construction and operation of shale oil recovery plants. Commercial development in Colorado and Utah. Shale distillation in Scotland. Retorting methods, with yield of products. Costs of refining shale oil in Scotland compared with costs of refining American shale oil. List of American processes for handling shale.

774—ENGLER, C., and TAUSZ, J. The Problem of the Constitution of Fossil Organic Matter and the Relation of its Solubility in Organic Solvents at Atmospheric Pressure and Excess Pressure to its Natural Mode of Formation. Z. angew. Chem., *34,* Aufsatzteil, 308-10 (1921); C. A., *15,* 3239.

Attempt to explain increase in solubility of bitumens and certain gums (amber, copal, dammar, pyropissite) in C_6H_6 as pressure and temperature increase. Shale oils with approximately 10% bitumen examined. Three parallel experiments made: (1) extraction with C_6H_6 at 80° only, (2) heating dry at 270°, then extraction with C_6H_6 at 80°, and (3) heating in autoclave at 270° with C_6H_6, then extraction at 80°. Extracts from (2) and (3) approximately same, each about 15% more than (1). Heat evidently agent in increasing solubility because of partial depolymerization. This action correlated with probable formation in nature of waxes, fats and resins through depolymerization. These in turn hydrolyze to form fauna and flora found in certain muds, clays and sediments. If process incomplete, ozokerite, adipocere and pyropissite formed.

775—FOXALL-SMEDLEY, F. E. J. The Scotch Oil Shale Industry. Petroleum World, *18,* 445-6, 448-52 (1921); C. A., *16,* 1500.

776—FRANKS, ARTHUR J. Chemical Engineering and Economies in Shale Oil Recovery. Chem. Age (N.Y.), *29,* 67-9 (1921).

Outline of problems of oil shale industry: (a) Carbonization of oil shale, (b) refining of oils, (c) development and utilization of by-products.

777—FRANKS, ARTHUR J. Studies in Colorado Shale Oils. Chem. Met. Eng., *25,* 49 (1921).

Results of investigations of shale oils and their fractions, with special reference to S and N content and to increased saturation by cracking.

778—FRANKS, ARTHUR J. Studies in Colorado Oil Shales. Chem. Met. Eng., *24,* 561-5 (1921).
Lighter hydrocarbon oil fractions more saturated than heavier fractions. Methods used in obtaining data. Graphical analysis of distillation cuts, showing temperatures, saturations, and specific gravities.

779—FRANKS, ARTHUR J. Colorado Shale Oils. Chem. Met. Eng., *25,* 731-5, 778-82 (1921); C. A., *16,* 640.
Effect of repeated distillations at atmospheric pressure determined on shale oil from DeBeque, Colo., shales, produced in Ginet retort. Light fractions very stable, and only slightly changed by redistillation. Heavy fractions decomposed easily, most of decomposition occurring in first distillation. Decomposition attended by gas formation, decrease in weight and volume of recovered oil, increasing stability and saturation of distillates, loss of S and N, and lowering of density. Decomposition begins at vapor temperature of 300°, but not appreciable below 320°. New saturated hydrocarbons formed by cracking, their source being heavy unsaturated bitumens, which are very complex, containing S, much N, and O. Lighter secondary products b.<276° chiefly paraffins and olefins, with some N bases, aromatics, diolefins and compounds of S and N. Theory advanced that in formation of oil from Colo. shales, heat first causes depolymerization of kerogen to heavy bituminous products, which then decompose, giving lighter stable oils.

781—FREEMAN, N. H. Producing Oil from Shale. Petroleum Times, *6,* 151 (1921); C. A., *15,* 3391.
Chief conditions to be observed in obtaining oil from shale are: shale must be finely divided, temperatures must be regulated, shale should be agitated to prevent trapping vapors, and vapors should be removed when educed and not subjected to higher temperatures. Production of oil from shale accompanied by transformation of heavier hydrocarbons into lighter and heavier parts. Norfolk shale having 27.45% organic volatile matter began distilling oil at 460° F. At 710° F., 41 gals of oil per ton of shale had been recovered. Above this temperature, waxes, tars, and heavy pitches carried over. It is concluded that any retort operating above 750° F., not suitable for retorting shales with recovery of oils as object and any advance in temperature above 750° F. approaches gas-producer effect.

782—GAISSER, F. C. Württemberg Oil Shales. Chem. Ztg., *45,* 837-9 (1921); C. A., *16,* 337.
Deposits extend for about 150 km. from Donaueschingen to Aalen, and conservatively estimated to contain 80 million tons of crude oil. Shale black; contains 16% of bitumen, part of which can be extracted by solvents. Numerous and well preserved fossils associated with bitumen indicate animal origin for organic material. Rock dense marl, consisting chiefly of $CaCO_3$ and silicates of Al, Ca, and Fe, with about 8% of FeS_2. Composition varies widely with locality. 16% of bitumen gave yield of 6-7% dark oil and 4-5% lighter oils and water. Sample of oil examined by Rau of Stuttgart (private communication) had d. 9447. About 5.1% of gas produced per ton of shale for each per cent oil. Large number of analyses given to show changes which mineral portions undergo during retorting.

783—GAVALA, JUAN. Shale in Spain. Bol. Inst. Geol. Espan., *42,* 265 (1921); Bull. Imp. Inst., *19,* 549 (1921); C. A., *16,* 2830.
Bed of bituminous shale and intercalated clay zone described, 4 mi. long, 1 mi. wide and 400 ft. thick. Reserves estimated at 24,000,000 tons which, with 4% yield, would produce 960,000 tons crude oil.

784—GAVIN, MARTIN J., and KARRICK, LEWIS C. Nature of Shale Oil Obtained from Oil-shale Assay Retort used by Bureau of Mines. Bur. of Mines, Repts. of Investigations, No. *2254,* 11 pp. (1921); C. A., *15,* 339.
Quality of shale oil produced with Bureau of Mines Retort (Karrick) when operated under conditions deter-

mined to be most suitable for producing highest yields of oil, shown by analysis to be nearly as good for shale oil made from shale from Soldiers Summit (Utah) as that of commercial Scotch shale oil. Scotch shale gave oil when retorted in Bureau of Mines retort which had an analysis very similar to that of Scotch shale oil produced in a commercial plant (Pumpherston).

785—GAVIN, M. J., HILL, H. H., and PERDEW, W. E. Present Status of American Oil Shale Development. Chem. Age (N. Y.), *29,* 305-10 (1921).

Oil shale well established industry in Scotland, decreasing in France, not yet on commercial basis in U. S. Properties of American oil shale given. Per cent of ash too high for use as direct fuel. Demand for gasoline for motor-driven machines not satisfied by present domestic output of crude petroleum. Foreign oil may supply deficit if in sufficient quantity and of reasonable price; oil shales next resort. Scottish practice described. American plants may have to sacrifice perfect yields for increased capacity. Economic factors affect choice of site for plant. Cost estimates vary. By-products important. Large plant investment required; unit of profit small. Technical, business and engineering skill of vital importance.

786—GAVIN, M. J., and BURROUGHS, E. H. Selected Bibliography on Oil Shale. Repts. of Investigations, Bureau of Mines, No. *2277* (Sept., 1921).

Selected bibliography covering period from 1915 to 1920, with classification according to subjects. Author index and also geographical index included.

787—GAVIN, M. J., and SHARP, L. H. Short papers from the Co-operative Oil Shale Laboratory. Co-operative Oil Shale Investigation. Bull. No. 1, Boulder, Colo. (July, 1921).

Relation of oil yield to heat of combustion and to various physical properties of raw shale discussed. Retorting time temperature and oil yield relationships shown by series of curves. Methods for making thermal calculations on retorting of oil shales and tables of physical constants included.

788—GAVIN, M. J., HILL, H. H., and PERDEW, W. E. Notes on the Oil Shale Industry, with Particular Reference to the Rocky Mountain District. Bureau of Mines, Repts. of Investigations, No. *2256,* 35 pp. (1921); C. A., *15,* 3904.

Short paper giving general discussion of subject and comprehensive list of references. Descriptive part of paper compiled from published articles and books for those interested only in general discussion of subject.

789—GAVIN, M. J. Past, Present and Future of the Shale Oil Industry. Cal. Oil World, *13,* 84-5 (1921).

Brief survey of industry and its possibilities, including growth and present status in France, Scotland, Australia and United States. Description of Scottish mining, retorting and refining methods. Discussion of problems to be solved in treatment of American shales for maximum yield of valuable products.

791—GEMMELL, R. B. Suggests "Shale Assay Ton" for Oil Shale Testing. Oil News, *9,* 40 (1921).

Suggests method for computing amount of oil distilled by using definite amount of shale for distillation.

792—GEOLOGICAL SURVEY. World Atlas of Commercial Geology. Washington. 72 pp. (1921).

A series of maps, with descriptive tables, showing the basic facts concerning both present and future sources of useful minerals. Section (pp. 17-23) on petroleum, oil shale and natural gas.

793—GEORGE, R. D. Oil Shale in Colorado. Railroad Red Book, *38,* 521-5 (1921); C. A., *15,* 2179.

Series of thin sections from shales giving an oil yield of 90-100 gals. per ton were prepared and examined under the microscope. In leanest shales, the organic materials were very scarce, while in richest shales the organic matter appeared to be more completely bituminized than in some of shales having lower oil content. Best material for microscopic examination is the dark mahogany brown, faintly lustrous shale. Waxy luster of certain shales thought not to be due to paraffin but rather to kaolin or related hydrous aluminum

silicate. Origin of shales, their structural features and weathering are described.

794—GEORGE, R. D. Comparison of Scotch and Colorado Shales. Railroad Red Book, *38,* 593-7 (1921); Petroleum Times, *6,* 51-2; C. A., *15,* 2179.

General discussion of problems of retorting and refining. It is highly probable that modifications of Scotch retorts and processes may be needed to meet peculiarities of our Colorado and Utah shales but broad needs are same.

795—GEORGE, R. D. Laboratory Study of Colorado Shales. Railroad Red Book, *38,* 734-8 (1921); C. A., *15,* 3741.

From experiments with mercury type retort connected with steam superheating device on one side and water-cooled condensing coil and series of receivers on the other, it was concluded most favorable range of temperatures for retorting Colorado shale between 280 and 340° C. and best temperature about 320° C. Crude oils obtained within this range yielded 33.7% straight run gasoline (up to 460° F.) and 20.7% kerosene (cut at 600° F.). Gasoline fraction averaged 54% saturated hydrocarbons, while kerosene fraction averaged 44.2% saturated. Gasoline scrubber placed beyond the NH_3 scrubber removed 6.4 gals. gasoline per ton shale treated. With superheated steam in retorting, yield of crude higher, yield of NH_3 nearly double, saturated content of gasoline higher (averaging 63.3%), kerosene yield larger but gasoline yield smaller, while gasoline yield in scrubber was 9.3 gals. per ton. Test run, in which temperature was raised to over 600° C. after all oil possible was taken off at 410° C., increased NH_3 yield from 19.5 to 25.2 lbs. per ton and converted fixed C. almost entirely into gases. Spent shale pale ash-gray and showed no tendency to cohere in masses.

796—GEORGE, R. D. Retorting Problems of Colorado Shales. Railroad Red Book, *38,* 793-6 (1921), 865-8, 929-33; C. A., *16,* 640.

Richness of shale, use of superheated steam, admission of air during retorting and temperature employed, all important factors in controlling formation of fixed gas. In general, it may be said that lower total fuel value of fixed gases in proportion to oil content of shale, more efficient the retorting process and higher the fuel value of fixed gases in proportion to oil content, less efficient the retorting. Retorting practice that results in formation of gas of high fuel value bad from other standpoints and yields poor grade of oil. Large NH_3 yield of shales, possible potash yield and proximity of phosphate beds of nearby states suggest possibility of artificial fertilizer industry.

Crude shale oil fractionated in various forms of apparatus. Best results obtained from crudes obtained by retorting at temperatures not exceeding 725° F. Crude from steam retorting at intermediate temperatures is best. Such oils yield rather uniformly 15-20% of crude gasoline and 30-35% of crude kerosene. Per cent of light oils commonly higher; per cent of unsaturated and aromatic compounds lowest, and oil more easily refined. But even then, per cent of unsaturated hydrocarbons ranges around 35-40%. Ten different analyses selected from over 750 distillation tests as follows: Gr. of crude 26.8-32.2° Bé.; gasoline 14.8-21.1%, gr. of gasoline 50.5-53.6° Bé.; kerosene 25.6-35.0%, gr. of kerosene 35-38° Bé.; gas oil 13.0-26.0%, gr. of gas oil 30.3-34.1° Bé.; light lubricating oils 14.6-20.5%, gr. of light lubricating oils 30.0-31.2° Bé.; heavy lubricating oils 9.5-15.4%, gr. of heavy lubricating oils 24.4-26.2° Bé.; coke and loss 1.4-7.0%. Average content of olefins in shale gasoline and kerosene 50% or over. To remove them would be to cut gasoline and kerosene yields in half and make acid treatment so expensive as to be prohibitive. Greatest refining problem, removing the dark brownish purple coloring matter of refined oil. If unsaturated hydrocarbons are preserved, coloration persists very stubbornly, but when entire non-paraffin matter is removed by acid and other treating methods, water white gasoline or kerosene easily obtained. Treatment with variety of materials (acids and salts) prior to acid treatment would remove color. Best results obtained by filtration through stratified layer composed of layers of clay from Pierre shale, layers of wood charcoal and layers of NaCl.

Nature of coloring matter not known, in spite of many tests. Apparently not of colloidal nature. Refining best carried out by treatment with 2% conc. H_2SO_4 and 4% NaOH (14° Bé.). Lubricating fractions treated with 4% conc. H_2SO_4, followed by 6% NaOH at 94° F. and then treated with Fuller's earth and filtered hot.

Light lubricating oils obtained from shale resembled gas engine oil in gravity, flash and burning points but viscosity much lower. In friction test, oil gave much lower coefficient of friction (0.013) and kept bearing at much lower maximum temperature than with heavier oils (124° F. as compared with 160° F. for heavier oils). Heavy lubricating oil probably called heavy cylinder oil, as is shown by its viscosity, flash and burning points. Very resistant to emulsification. Coefficient of friction gave minimum of 0.01 while maximum temperature of the bearing was 146° F. Test made in which results obtained by dry distillation of shale compared with those given by use of superheated steam furnished by gypsum placed in retort. With superheated steam, yield of crude oil increased 20 gals. per ton (60%); $(NH_4)_2SO_4$ increased by 13.31 lbs. per ton (300%); gasoline yield from crude by dry distillation more than doubled, while kerosene reduced by half. These differences caused by destructive distillation. Most satisfactory procedure for distilling crude seems to consist in taking off gasoline and kerosene as usual, then running down to residual oil in a coking still until only soft asphaltic tar left in still. Distillate so formed would be about 60% by volume of crude. This cracks readily and yields about 40-50% its volume of gasoline by usual methods, or, if cracked in 2 or 3 stages, cooling, and removing settled C., yield may be brought up to 60-65% of volume of distillate used. Cracking tests on shale kerosene at pressures from 70-100 lbs. and temperature from 785 to 860° F. showed yield of gasoline at higher pressure and higher temperature averaged over 40% higher than at lower pressure, being 20.5% and 14.2%, respectively.

797—GEORGE, R. D. Oil Shale in Colorado. Railroad Red Book, *38*, 457 (1921).

Location of oil shale areas of state; topography, drainage, climate, etc., of area, and geologic occurrence of shales.

798—GINET, J. H. The Commercial Treatment of Oil Shale. Shale Rev., *3*, 3, June (1921).

Discusses following three essentials for successful development of industry: (1) dependable market, (2) abundance of raw material, (3) efficient means or process of converting raw material into finished product.

799—GINSBERG, I. Colloidal Chemistry is Useful in many Industrial Processes. Oil, Paint, Drug Rep., *99*, 24, May (1921).

Review of most important industrial applications of colloidal chemistry, including recovery of petroleum from oily muds and proposed treatment of shales by a colloidal process for recovery of oil.

801—GINSBERG, I. Colloidal Mills and Ultra-Filters. Oil, Paint, Drug Rep., *100*, 24 (1921).

Describes apparatus used in adapting principle of colloidizing to large scale industrial processes. Includes diagram and description of proposed plant for extracting oil from shale by a colloidal process.

802—GRAY, ALEXANDER. Anglo-Persian Activity in New Brunswick Oil Shales. Can. Mining J., *42*, 474-9 (1921).

Account of previous work in developing and testing New Brunswick shales and present work of the Anglo-Persian Company with 8-ton plant using Wallace process. Oil shales of New Brunswick, Utah, Colorado and Wyoming are described as "The second line of industrial defense." Includes analysis of shale and report on geological survey by Sir Boverton. On Sir Boverton's recommendation the Anglo-Persian Oil Company and D'Arcy Exploration Company are working together on this problem.

803—GRIMES, O. J. Petroleum and Oil Shale in Colorado. Railroad Red Book, *38*, 465 (1921).

Report of status of a number of companies and activities in western Colorado.

805—HAGUE, R. H. Notes from the Pas: Gold, Copper and Oil Shale

Prospects. Can. Mining J., *42*, 515 (1921).
Résumé of report by R. C. Wallace, giving yield of oil and NH_3 from a shale along the Man River, Canada.

806—HARTLEY, CARNEY. Oil Shales in the Rocky Mountains. Mag. N. Y. Petroleum Exchange, *2*, 67 (1921).
On the present status and possibilities of shale oil industry in Rocky Mountain district.

807—HELLSING, GUSTAF. Contribution to the Knowledge of Composition of Swedish Shale Oil. Arkiv Kemi, Mineral, Geol. Stockholm, *7*, No. 29, 23 pp. (1921); C. A. *15*, 3552.
Shale oils from various localities examined. Distilled from wrought iron cylinders of 20 liters capacity at low red heat without use of steam. Raw oil, brown in color, d. 0.9595 fractionated at temperatures varying from 75° to 330°, 25 fractions being taken. Higher temperature fractions found high in S. 75° fraction gave qualitative tests for acetone, though none separated out when usual methods tried. Dinitrotoluene found upon nitrating fraction 118°-125°. Toluene found in fraction 125°-132°. P-trinitroxylene obtained from 132°-145° fractions. Br yielded dibromoxylene from 145°-155° fraction. From 155°-162° fraction sulfonation produced trimethylbenzenesulfonamide. Fraction 162°-175° yielded pseudocumene, which also found in fractions up to 200°. In fraction 200° to 210° tetramethylbenzene was found, while fraction 210°-225° yielded dibromotetramethylbenzene. This high content of aromatic compounds definitely distinguishes Swedish shale oil from both Scotch and French shale oils.

808—HELLSING, GUSTAF. Bitumen Content of Swedish Alum Shale. Teknisk. Tid., *51*, 73-9, 85-7, 89-93 (1921); C. A. *16*, 1009.
Samples of alum shale analyzed by method previously described. Following gives extreme percentages of large number samples as tabulated: ash, 68.9-82.3; H_2O, 0.9-4.8; oil, 1.2-7.0; gas, 2.3-7.0; coke, 83.-92.; S, 3.6-9.6. Gas has following general composition: CH_4, 5.9; CmHn, 0.4; H_2, 3.9; CO, 4.1; H_2S, 2.1; CO_2, 12.4; O_2, 2.8; N_2, 68.3.

809—HILL, H. H. Substitutes for Gasoline as a Fuel described by an Expert. Oil, Paint, Drug Rep., *99*, No. 5, 12 (1921).
Reserve source of oil in oil shales in this country that can meet practically any future demand for motor fuel. Motor fuel from shale has not been marketed in this country but has been used in Scotland and England for several years.

811—JENSON, J. B. The Colorado-Utah Petro-Shales, I. Petroleum Times, *6*, 469-70 (1921); C. A. *15*, 3904 (1921).
Suggested nomenclature relative to shale products to clarify certain inaccurate and misleading expressions now in use.

812—JENSON, J. B. Colorado-Utah Petro-Shales, II. Petroleum Times, *6*, 489-90 (1921). Cf. C. A., *15*, 3904 (1921).
Best yield of oil from shale produced from unweathered shale. Falling off in production of crude oil very marked when retorting weathered shale.

813—JENSEN, H. I. Oil Shale. Queensland Govt. Mining J., Mar., 1921, p. 92; Oct., 1921, p. 401; Bull. Imp. Inst., *19*, 548-9 (1921); C. A., *16*, 2777.
Walloon area (Jurassic) appears to contain numerous seams of kerosene shale or torbanite, yielding 44.8 to 54 gals. to ton.

815—JENSON, J. B. American vs. Scotch Methods in Retorting of Petro-Shales. Salt Lake Mining Rev., *22*, 17-23 (1921).
Explains principal operations of Scottish retorting and tells why these methods are not applicable successfully to American shales. Discusses advantages of Jenson eduction process.

816—JENSON, J. B. Petro-Shale Products of Western Slope. Salt Lake Mining Rev., *22*, 19, Feb. (1921).
Costs and production figures for different shales. Refining problems and value of products.

817—JILLSON, W. R. Economic Papers on Kentucky Geology. Kentucky Geol. Survey, *2*, Series 6 (1921).

Collection of papers on geology of Kentucky including report on occurrence of oil and gas, oil shale, asphalt rock and fluorspar. Includes bibliography on shales.

818—JILLSON, W. R. A preliminary Report on the Oil Shales of Kentucky. Ky. Geol. Survey, Econ. Papers on Ky. Geol., Series *6*, 1-38 (1921); C. A. *16*, 2402.
With composite outcrop acreage of Devonian black shale in Kentucky as 609,920 acres and empirically assumed thickness of 20 ft., total tonnage figure may be obtained for this state that is stupendous. Average oil content of 16.08 gals. per ton when multiplied by this tonnage gives possible recoverable quantity of tarry oil of over 12 billion barrels. Distillation and analysis of over 20 samples of Devonian black shale from almost as many different counties gave following average results: oil content 16.08 gals. per ton, d. 2.173, weight 129.37 lbs. per cu. ft., S 1.5-4.15%, combustible matter 10.-16.%, fixed carbon 4.5-10.% ash 73-90%.

819—JONES, J. R. Legal Status of Oil-Shale Deposits on the Public Domain. Eng. Mining J., *3*, 68 (1921).
Gives provisions of act of February 25, 1920, relating to oil shale deposits and discusses requirements of the law.

821—KARRICK, L. C. A Convenient and Reliable Retort for Assaying Oil Shales for Oil Yield. Bureau of Mines Report of Investigations, Serial No. 2229, 7 pages; Salt Lake Mining Rev., *22*, 21-3, March (1921).
Detailed description of retort with diagram and reasons for selection.

822—KIRKPATRICK, W. C. Shale Oil Costs Less Than Well Oil. Shale Rev., Aug.-Sept., p. 3, October, p. 4 (1921).
Figures presented to show that shale oil costs less than well oil.

823—LAZENNEC, I. The Shale Oil Industry. L'Age de fer., *37*, 931 (1921).
Brief description of mode of occurrence and methods of extraction and distillation of shale, and of products of distillation and method of purification.

824—LITINSKY, L. Oil Shale Industry in Russia. Petroleum Z., *17*, 368-71 (1921); C. A., *16*, 1661.
General description of several shale deposits of Russia.

825—LITINSKY, L. Oil Shale Industry in Russia. Petroleum Z., *17*, 405-8 (1921); C. A. *15*, 3740.
Work progressing in 3 different places on development of oil shale. Examination of bitumen under microscope shows it to be of animal origin. Shales contain 34-38% volatile substances, 50% ash and 8-11% tar. Properties of crude oil obtained resemble those of tar obtained from sapropelite. Slow distillation produces more oil while higher temperature yields more gas. Further distillation of oil and separation into fractions shows that from oil one obtains 6.78% benzine (up to 150° C.), 23.25% kerosene (up to 270°), 21.77% high-boiling products (up to 320°), distillation loss 13.5%. Sp. gr. of fraction between 300 and 320° C., 1.067 flash 15°, viscosity at 50°, 5.4. Yield 20% of weight of crude oil. Product excellent for use as machine oil, especially when flash point raised. Ichthyol obtained from distillation as well as NH_4 salts and thioichthyolic acids. Pitch waste, after complete removal of volatile constituents, removes colors from solutions. It can be used as decolorizing agent in sugar and other industries. Oils from Russian shales of 2 types: those obtained at higher temperatures in artificial gas manufacture and those obtained by distillation at lower temperatures. Benzine comparable with that obtained from brown coal distillation, having sp. gr. of 0.788 at 15°. Kerosene burns in lamps provided with flat burner without producing soot and smoke and lubricating oil fraction has given satisfactory results.

826—LITTLE, A. D. The Fuel Problem. Atlantic Monthly, *127*, 190-9 (1921).
Discusses problems involved in supply of coal, oil, gas and electricity for fuel. Includes discussion of oil from shale, peat and lignite, and of colloidal fuel.

827—LOGAN, W. N. In Case of a Petroleum Shortage. Oil News, *9*, 17, Feb. (1921).
On possibilities of substitute fuels from torbanites, oil shales and coal.

828—LOMAX, E. LAWSON, and REMFRY, F. G. P. The Laboratory Testing of Oil Shale for Oil and Ammonia Yield. J. Inst. Petroleum Tech., *7*, 24-47 (1921); Shale Review, *3*, 3, March (1921); Mining and Met., *45*, April (1921).
Sampling of shale. Preparation of sample. Retorting, with illustration of apparatus. Experimental refining. Determination of fixed carbon, also nitrogen. Notes on weathering of shale.

829—LOW, A. H. The Distillation of Oil Shale. Petroleum Times, *5*, 689-90 (1921); C. A. *15*, 2716.
Description of process for preliminary testing of oil shales with oil as primary consideration as adopted in Colorado School of Mines.

831—LOW, A. H. The Colorado School of Mines Method for the Distillation of Oil Shales. Quarterly Colo. School Mines, *16*, 13 Apr. (1921).
Describes method employed for preliminary testing of oil shales.

833—McCLAVE, JAMES M. Flotation Oils from Shales. Railroad Red Book, *38*, 25-7 (1921).
Historical development of flotation. Flotation oils described. Shale flotation oil first used in 1915. Commercial development of shale oil.

834—McCLAVE, J. M. Flotation Oils from Shale. Petroleum Times, *6*, 11-12 (1921); C. A. *15*, 3391.
It has been found that the method of eduction and temperature of treatment are important factors in the production of shale oils for flotation purposes. There are certain cuts that will yield high-grade flotation oils which will produce clean concentrates with a high recovery. Owing to lack of uniformity in retorting processes, the crude shale oil is not satisfactory.

835—McKEE, RALPH H., and LYDER, E. E. Apparatus for Studying Thermal Decomposition of Oil Shales. Chem. Met. Eng., *25*, 1100-1 (1921); C. A., *16*, 825.
A gas-fired, horizontal rotary retort having a charging capacity of 25 lbs. of 0.25 in. mesh shale is recommended. A stock-type furnace (No. 84) of the Am. Gas Furnace Co., Elizabeth, N. J., is used by McKee and Lyder. The accessories for temperature control, steam generation, condensation, etc., are described briefly.

836—McKEE, RALPH H., and LYDER, E. E. The Thermal Decomposition of Shales, Heat Effects. J. Ind. Eng. Chem., *13*, 613-18 (1921).
Kerogen does not decompose to form petroleum oils as primary product of decomposition but first substance obtained is heavy solid or semi-solid bitumen. This bitumen first formed rapidly at a quite definite temperature, formation taking place between 400° and 410° C. with this particular shale. Petroleum oils formed from oil shale are result of decomposition by cracking of first formed heavy bitumen. It is possible to design shale retort to be used simultaneously as cracking still for shale bitumen and heavy residue from well petroleum.

837—McKEE, RALPH H., and LYDER, E. E. Thermal Decomposition of Shales, Heats of Reaction. J. Ind. Eng. Chem., *13*, 678-84 (1921).
Heat of reaction: from 421 to 481 calories absorbed per gram of oil and gas produced. Coefficient of heat conductivity of oil shale: 0.00086 expressed in c. g. s. units.

838—MARCUSSON, J., and PICARD, M. The Composition of Pitch Tars. Mitt. Material-prüfungsamt, *39*, 329-34 (1921); C. A., *16*, 4329.
Article deals with tars obtained from lignite, bituminous shale and peat. Distillation methods avoided since decomposition of characteristic constituents of tar would result. Presence of ketones of interest to petroleum specialists, since Kunkler and Schwedhelm in 1908 put forward theory that ketones are intermediates between Ca salts of fatty acids and hydrocarbons.

839—PEARSE, A. L. The Refining of Oil Shale. Mining Sci. Press, *122*, 151 (1921).
Outlines results of recent experimental work in rapid distillations of shales. Points out necessity of suiting processes used to peculiar characteristics of shale treated.

841—REEVES, JOHN R. Investigation of Oil Shales by Indiana Geological Survey. Eng. Mining J., *110,* 954 (1920); Shale Rev., No. 12, 12 (1921).

Geological discussion of Indiana shales. Thickness 100 to 140 ft. Yields 10-30 gals. oil, 5-30 lbs. $(NH_4)_2SO_4$, 4-6 lbs. pyridine, and 500-2500 cu. ft. gas per ton shale.

842—SHARP, L. H. Some Items of Investment, Expense & Profit in Commercial Shale Oil Production. Bur. Mines Rept. of Investigations No. 2214, 3 pp. (1921); C. A., *15,* 1210.

Brief and general discussion of sources of revenue, items requiring capital investment and factors comprising manufacturing and selling cost of shale oil plants in this country.

843—SHARP, L. H., and STRUNK, A. T. Some Items of Investment, Expense and Profit in Commercial Shale Oil Production. Chem. Age (N. Y.), *29,* 69-70 (1921); Oildom, *12,* 47, March (1921); Oil, Paint, Drug Rep., *99,* 8, Feb. (1921); See Abstract 842.

844—SIMPSON, LOUIS. Plant Design for Hot-Gas Pyrolitic Distillation of Shale. Chem. Met. Eng., *24,* 341-44 (1921).

Description and plan of 2000 ton per day shale oil plant operating on indirect heating process. Hot gases used to convey reacting heat and resultant oil vapors from pyrolysis of shale. Floor plans for plant and cross section retort drawings. Cost estimate for operating plant.

845—SMITH, J. T. New Oil Shale Plant Demonstration is Success. Salt Lake Mining Rev., *23,* 2 (1921).

Brief account of test of a Genit plant near DeBeque, Colorado.

846—SPIEGEL, ADOLF. Shale Oil. Darmstadt. Z. angew. Chem., *34,* Aufsatzteil, 321-7 (1921); C. A., *15,* 3391.

Presentation of chief points of interest in shale oil industry. Shale origin in nature, occurrence and composition, commercial apparatus for distilling shale, and shale oil uses treated in detail.

847—SQUIRES, R. A. Dominion of Newfoundland as an Oil Producing Country. Cal. Oil World, *13,* 67, May (1921).

Discusses possibilities of oil from wells and from oil shale in Newfoundland. Includes analysis of Newfoundland shales.

848—THIESSEN, REINHARDT. Origin and Composition of Certain Oil Shales. Econ. Geol., *16,* 289-300 (1921); Bull. Geol. Soc. Am., *32,* 72 (1921); C. A., *15,* 3807.

Preliminary report on microscopical study of oil shales, which was undertaken in hopes of establishing definite correlation between results of microscopic examination and those of distillation experiments. Chocolate shale of Devonian of Illinois was made basis of study. Oil shales from Indiana, Ohio, Kentucky, Tennessee, New York, Nevada, Utah and Scotland also examined. Material examined in thin sections and organic matter freed from mineral matter by means of mixture of HF, HNO_3 and HCl and examined separately. Conclusions: (1) As far as examined, oil shales do not contain oil as such; (2) oil distilled therefrom derived from organic matter contained in them; (3) all identifiable organic matter consists of plant matter or degradation products; (4) organic matter consists essentially of spores and cuticular matter in varying proportions together with some woody degradation products; (5) no animal matter recognized; (6) although work already done insufficient to form basis for positive conclusions, it would seem that oil shales of different geological history, composition, structure and physical characteristics should yield different distillation products and require different methods of treatment.

849—THIESSEN, REINHARDT. Origin and Composition of Certain Oil Shales. Petr. Times, *6,* 617-8 (1921); C. A., *16,* 640.

Microscopic study of oil shales shows that shales do not contain oil as such but that oils distilled from them are derived from their organic constituents. All organic material identified in these shales vegetable. Larger part of organic constituents consists of spores, these being present in different proportions in differ-

ent samples. Considerable amount of cuticular material and some woody degradation matter also present, but little or no resinous substance in shales. Since their deposition, these spores and cuticles have undergone changes resulting in the loss of oxygen similar to changes in formation of coals in general. In consideration of their original composition, they would be expected now to yield paraffins and olefins on distillation. Exceedingly desirable to correlate results of microscopic investigation with results of distillation experiments in the hope that microscopic examination will prove to be valuable aid in appraisement of oil shale.

851—THOMAS, KIRBY. Possible Uses for Spent Shale from Oil Shale Operations. Chem. Met. Eng., *24,* 389 (1921).

Suggests its use as fuel, as insulating material for electrical applications, as material for brick making, use in cement industry.

852—URBAIN, ED. and G. The Extraction of Shale Oil. Bull. official direction recherches sci. ind. inventions, *1921,* 430-2; C. A., *16,* 825.

Shale studied yielded 44% volatile matter, which consisted of H_2O, 20; oil, 14.2; gas, 9; and NH_3, 0.4%. Gas consisted of CH_4, 12; C_2H_4, 5.5; CO, 55; and N, 27.5%. 133,000 cal. must be supplied to dry distill a ton of shale. Heating in current of hot inert gas increased yield of oil and adding small quantities of CaO increased that of NH_3. Sketch of proposed continuous furnace in which temperature will not exceed 400° C. given.

853—WALLACE, R. C. The Search for Oil in the Pasquia Hills. Can. Mining J., *42,* 540 (1921).

Topography and geology of region and possibilities of shales and oils from wells.

854—WEBB, FRANCIS P. Present Availability of Oil Shale. Am. Gas J., *115,* 271-2 (1921); C. A., *15,* 3904.

Index Shale Oil Co.'s retort described. Horizontal, tubular retort with positive feed, but with no moving interior parts. Capital cost far below that of other types and does not exceed $350 per day ton. Highest throughput known, greatest flexibility at all stages and perfect heat control allowing of great variations in range of distillation. Residue delivered in powdered form, calcined or with fixed amounts of hydrocarbons. It can be applied to coal distillation with recovery of by-products.

855—WILLIAMS, M. Y. Oil possibilities of Manitoulin Island. Can. Dept. Mines. Summary Report *1920,* Pt. D, 26-33; C. A., *16,* 542.

An oil spring discovered about 1650. Some drilling done. Results of recent work prove oil not present in commercial quantities. Logs of 5 wells given. Analyses of 3 samples of oil gave 54, 48 and 46%, respectively, of distillate below 350°. Oil shale of this region contained 65% ash and 35 volatile matter. B.t.u. per lb. 1720, oil yield per ton 7.7 U. S. gal., gas yield 740 cu. ft. per ton B.t.u. of gas 540 per cu. ft.

856—WILLIAMS, H. E. Oil Shales and Petroleum Prospects in Brazil. Trans. Am. Inst. Mining Met. Eng., *16,* 69-77 (1921); C. A., *16,* 2777.

Samples of oil shales from central Maranhãvo gave following results on analysis: bitumen 36.5%, clays 22.6%, carbonates 40.8%, and on slow distillation about 100 gals. oil per ton shale. Samples of shale from parts in Alagoas district contained from 7.8 to 46.3% volatile combustible and 34.2 to 89.3% ash (series of 10 determinations). One sample had 4.7% S and upon distillation yielded 44.73 gals. oil. In Bahia, the boghead coal known as the "Turfa de Marahu" is found. Great mass of this composed of yellowish, brownish humic material. Analysis gave: H_2O 2.75%, volatile matter 71.65%, non-volatile combustible matter 9.75%, mineral residue 15.85%.

857—WRAY, D. A. The Oil Resources of the Serb-Croat-Slovene State. Petr. Times, *6,* 649-51 (1921); C. A., *16,* 639.

Gases, oil and petroleum probably formed in, or introduced into beds in which they now occur shortly after deposition of sediments. Where evaporation of liquid products has ensued solid contents concentrated producing ozokerite and allied products. Where oxidation has taken place as where atmospheric agencies are free to act, an asphalt rock results. Asphaltic shales associated with asphaltic limestones contain 7.12% as-

phalt, 58.1% Fe_2O_3 and Al_2O_3, 1.10% Fe carbonate, 32.58% $MgCO_3$, and 0.97% NaCl. Paraffin shales are associated with thin beds of clay containing salt. Shales gave: hydrocarbon oils 30.25%, hydrocarbon wax 1.75%, H_2O 3.02%, carbonaceous matter 2.94%, Al_2O_3 30.24%, Fe_2O_3 4.79%, MgO 1.16%, CaO 1.11%, K_2O 2.0%, Na_2O 0.38%, SiO_2 53.0%. Shales on distillation yield 45 gals. oil per ton of shale. Crude oil gave 30% burning oil, 4.5% intermediate oil, 155.5% lubricating oil and 14.3% paraffin scale.

858—AKYROYD, H. E. Significance of England's Oil Shales. Petroleum Times, *7*, 576 (1922); C. A., *16*, 3197.
Great profits of oil industry have hindered scientific investigation in this industry. Scottish industry has treated shale almost entirely for NH_3 and paraffin. Industry must be reorganized so as to make these by-products. S can now be easily eliminated. Externally heated retort is being replaced by internally heated retorts. Superheated steam heated to not more than 400° C. will be the medium used for distillation. This results in a higher yield of NH_3. Oil from shale is highly unsaturated but easily converted into 90% saturated. Its high content of aromatics enhances its value as a motor fuel. Present cracking methods are not good but the use of hyzone (H_3) discovered by Bergius appears to make this process more efficient.

859—ALDERSON, VICTOR C. The Oil Shales of Kentucky. Railroad Red Book, *39*, 923-7 (1922); C. A., *17*, 338.
Description of location and formation of the Kentucky shale deposits. Estimated that 1000 sq. mi. are exposed and available for exploitation by open cut and steam shovel methods. Shale yield 16 gals. oil per ton and has a sp. gr. of 2.17, S content of 1.5 to 4.1, N content of 0.26 to 0.57, moisture content of 0.83 to 1.59, volatile combustible matter from 16.72 to 10.26, fixed C 4.61 to 10.06, ash 75.43 to 83.90%. Kentucky shale will also produce $(NH_4)_2SO_4$, and other products.

861—ALDERSON, V. C. Oil Shale. A Résumé for 1921. Petroleum Times, *7*, 259 (1922).
Résumé of operations in Utah, Colorado, Canada, Kentucky, Esthonia, Palestine, South Africa, Sweden and Tasmania. Needs of the industry are manufacture of few marketable products, services of technical men and better type of retort to produce maximum yield of good oil.

862—ALDERSON, V. C. Oil Shales of Kentucky and Russia. Quarterly of the Colorado School of Mines, *17*, No. 4, Oct. (1922); Petroleum Times, *8*, 751 (1922); 796 (1922); Railroad Red Book, *39*, 923-7 (1922).
Oil Shale of Kentucky forms bluffs of 250 miles length with average thickness of 50 ft. and available shale of 90 billion tons. These shales produce an average of one-half barrel of crude oil per ton. Nitrogen content is high and $(NH_4)_2SO_4$ will be valuable product. Gas produced by distillation of shale is more than ample for production of the heat necessary for distillation. Analyses of shale and crude oil given. Russia has oil shale deposits in five localities but development has been slow due to economic conditions. Shale from Wiemarn is used in Petrograd and Kronstadt as raw fuel in gas production. One of the distillation products of Kaschpur shale is ichthyol.

863—ANON. The Shale and Coal-oil Industry. Petroleum Times, *7*, 311-12 (1922); C. A., *16*, 1660.
The early history of the shale and coal-oil industry is given.

864—ANON. Distilling Oil Shales without Retorts. Petroleum Times, *7*, 510 (1922); C. A., *16*, 2219.
Sections of Australian shale beds blocked out and bricked in and sufficient air supplied to maintain desired rate of combustion, this supply is under regulation and therefore controls burning of shale. Early trials stated to have been successful and that oil was given off in abundance as well as large quantity of gas suitable for generating power. Shale used of exceptional richness, yielding from 100-150 gals. oil per ton shale. Possibility of using method presumably limited to cases where shales are exceptionally rich in organic matter and for cannel coal and torbanite.

865—ANON. New Method of Treating Oil Shales. Petroleum Times, *7*, 262 (1922).

Brief review of the Dolbear system of flotation of pulverized shale to separate the organic and mineral matter before retorting.

866—ANON. A Successful Oil Shale Plant. Petroleum Times, *7*, 156 (1922).
Western Oil Shale Company of Grand Junction, Colo., said to be producing shale oil at cost of $1.00 to $1.25. Volatile matter removed only to point of maximum efficiency, the hot residue retaining sufficient fuel value to be used immediately after transfer from the retort to the firebox.

867—ANON. Some Unsolved Oil-shale Problems. Petroleum Times, *7*, 597 and 631 (1922).
Discussion of needs of investigation of specific problems chosen from pure science and technical sides of question of shale oil recovery, special emphasis being placed on retorting problems.

868—ANON. Does Oil Exist in Oil Shale? Petroleum Times, *7*, 199 (1922).
Tests by the U. S. Bureau of Mines. Attention is called to belief that oil does not exist as such in oil shales, based mainly upon insolubility of organic matter of shales in ordinary petroleum solvents. Writer calls attention to fact that extracted material, though not oil according to common meaning of term, is like certain hydrocarbons which result from the oxidation of petroleum. A table of per cent extraction by different solvents on various shales is appended.

869—ANON. Refining of Shale Oil Naphtha. Chem. Age (London), *7*, No. 165, 209 (1922).
Best results obtained at Boulder, Colorado, by U. S. Bureau of Mines in refining shale oil naphtha obtained by the use of 70% sulfuric acid followed by regular water and caustic soda wash and doctor treatment.

871—ANON. Refining of Shale Oil. Chem. Age (London), *7*, No. 167, 287 (1922).
Scrubber naphtha recovered from activated charcoal absorber of poor quality. Retort gases must be scrubbed to obtain low boiling gasoline for blending with less volatile fractions. Activated charcoal is suggested as more satisfactory than ordinary oil scrubbers.

872—ANON. Oil Shales of Esthonia. Pet. World, *19*, No. 258, 104 (1922).
Describes the extent of the area and the development to date.

873—ANON. The Fusion Patent Shale Retort. Petroleum Times, *8*, No. 183, 70 (1922).
Essential features to be considered in retort designing discussed. Fusion rotary retort materially different from other rotary types and promises to occupy a prominent place. Prevents scale formation and obviates caking of retorted material. Results of tests on representative shales given.

874—ANON. The Turner Shale Retort. Petroleum Times, *8*, No. 185, 122 (1922).
The Turner retort is to be used in retorting Norfolk shales.

875—ANON. The Oil Shale Industry and its Problems. Petroleum Times, *8*, No. 185, 145 (1922).
Excerpts from brief of Mr. Robert D. Hawley, attorney for one of the parties to the litigation in the case tried in the U. S. Land Office at Glenwood Springs, Colorado. Oil shale as an ultimate factor in oil production and an established industry in working the oil shales is not doubted by those who are familiar with American oil shale resources.

876—ANON. Developing the Norfolk Oil-Shales Fields. Petroleum Times, *8*, No. 186, 157 (1922).
Discussion of the Turner Retort. Interview with the inventor.

877—ANON. Retorting of Oil Shales. Petroleum Times, *8*, No. 188, 233 (1922).
Description of low temperature carbonization plant near Bombay. Probability of its adaption to western U. S. shales is suggested.

878—ANON. Experimental Distillation of shales. Petroleum Times, *8*, No. 188, 250 (1922).
Experimental investigations indicate that stationary and revolving retorts give

equivalent results in quality and quantity of oil when in both progress of distillation of shale is identical. Low temperature (preferably not exceeding 460°) distillation produces best oil. 80% of oil forming material of the shale is rendered soluble in CS_2 by heating. This was not oil but the product decomposed to shale oil at about 390° C.

879—ANON. Sulfur in Shale Oils. Petroleum Times, *8,* 331-2 (1922); C. A., *16,* 4055.
Present methods of treating oils to remove S compounds are listed and discussed. $PbSO_4$ is suggested as a desulfurizing agent because of its non-emulsifying qualities and the ease of regenerating the sulfate from the sulfide.

881—ANON. South African Oil Shales. Petroleum Times, *8,* No. 197, 578 (1922).
Further exploration in South Africa by the Dutch Oil Company will not be continued at the present time.

882—ANON. The Oil Shale Position in South Africa. Petroleum Times, *8,* No. 197, 580 (1922).
Development is suggested by small local mining companies, equipped with retorts and conveying their product by means of a joint pipe line to a central refinery. F. W. G. Brown estimated gross returns of £2 per ton of shale at a cost of £1 per ton, making the profit £1, using a 300 ton per day plant. The estimated cost of the plant is £150,000. Paying of bounty by government might aid as an impetus toward development.

883—ANON. Another New Process for Shale Distillation. Petroleum Times, *8,* No. 198, 599 (1922).
A continuous process carried out at the Buffalo Foundry and Machine Company's plant at Buffalo. Low temperature distillation produces 26.5 gals. of uncracked oil per ton of Kentucky shale.

884—ANON. Developing the Norfolk Oil Shale Fields. Petroleum Times, *8,* No. 199, 638 (1922).
Provisions of the license granted to the Pentney Syndicate, Ltd., for developing Norfolk Shales.

885—ANON. The African Oil Corporation, Ltd. Petroleum Times, *8,* No 201, 731 (1922).
After extensive investigation, the Royal Dutch Shell has decided to not exercise their option. Development will be continued by a local corporation.

886—ANON. Retorting Oil Shale on a New Principle. Petroleum Times, *8,* 746 (1922).
The Hampton-Ryan digestion process is described.

887—ANTROPOFF, A. The Oil Shale Development and the Oil Shale Industry in Esthonia. Z. angew. Chem., *35,* 647-51 (1922).
Location and geologic formation described. Shale of animal origin and estimated to consist of one and one-half billion tons. Burns readily with a sooty flame. Utilized for fuel, gas and oil products. The bitumen content is 49.8% and yields 20% by weight of oil. Distillation is by means of internal heat, preheated flue gases supplied from distillation chamber from shale, being used.

888—BAILEY, EDWIN M. The Shale-oil Industry of Scotland. J. Inst. Petroleum Tech., *8,* 465-90 (1922). C. A., *17,* 1326.
Complete but concise description of equipment and processes of Scottish shale-oil plant given.

889—BARRETT, N. O. Illinois. Bituminous Shales. Ill. State Geol. Survey, Bull. No. *38,* 441-60 (1922). C. A., *17,* 1711.
Shale deposits of nine counties described. Oil ranged from 0 to 48.8 gals. per ton. An average would be misleading but of 18 samples, 5 yielded 36.0-48.8 gals.; 6 yielded 11.6-16.4 gals., and 7 yielded 0.5-4.5 gals. per ton. Some giving little oil yielded much gas.

890—BACON and HAMOR. American Fuels. *1,* 394-515 (1922).
The Distillation of Coal at Low Temperatures, Chapter VII of book, was written by F. Parkman Coffin.

891—BERGH, SVEN V., and LARSEN, K. E. Shale Industries in Germany, France, Great Britain and Norway. Teknisk Tidskrift, *52,* 305-15 (1922); C. A., *16,* 2598.

Report of a tour of inspection. Maps, photographs, sketches and several analyses.

892—BOTKIN, C. W. Relation of Shale-oil Residue to Other Bitumens. Chem. Met. Eng., *26,* 445-8 (1922). C. A., *16,* 1501.
The products obtained by distilling heavy "shale-oil residue," gilsonite, asphalt, and rosin from an Engler flask and at ordinary pressure are compared as to sp. gr., boiling range, N content, and unsaturation. The "shale-oil residue" and gilsonite each contained 2% of N, of which 72.8 and 76.3%, respectively, were lost during the distillation. This indicated that high molecular weight N compounds were decomposed. Per cent of "saturated" in products obtained by distilling each material, except rosin, decreased fairly regularly with increase of boiling point of the fraction examined.

893—BOTKIN, C. W. Saturated and Unsaturated Oils from Shale. Chem. Met. Eng., *26,* 398-401 (1922); C. A., *16,* 1501.
Fifty-cc. portions of crude shale oils from Utah, Wyoming, Kentucky, California, England and Scotland were distilled from a 100-cc. Engler flask at a rate of 1 drop per second. The crude oils decomposed thermally, forming coke, oils, and gas. Oils so formed lower sp. gr. and contained more saturated hydrocarbons than crude oils. N content of the distilled oil higher than corresponding crude oils. Crude oils obtained by retorting Colorado shale with steam contained 13.6% of gasoline that was 50% saturated. Same shales at higher temperatures and without steam produced 29% of gasoline that was 52.4% saturated. Gasoline is distillate to 410° F. Since prevention of cracking diminishes yield and does not improve quality, it is not justified insofar as retorting procedure determined by gasoline yield.

894—BOTKIN, C. W., and BOYD, R. W. Oil Shale Unsaturates. Petr. Age, *10,* No. 11, 78-85, and No. 12, 26-27 (1922); C. A., *17,* 465 and 629.
Experiments conducted to determine unsaturation by iodometric methods. Hanus method gives lower I number when excess of I small, and higher number when excess of I larger, than is obtained by Hubl method. With large excess of I neither method reliable. Hubl-Waller solution gives more nearly constant results with varying excesses and is, therefore, more desirable for determination of I number of shale oils. Hanus solution apparently better fitted for detection of diolefins by Faragher's method. Diolefins present in light fractions and probably in heavy fractions of once run oil. The I number of crude oil only slightly higher than that of once run oil, yet H_2SO_4 absorption of crude oil much greater. Light fraction with an I number 2.5 times that of heavy fraction has a H_2SO_4 absorption only 0.75 times that of heavy fraction.

895—CAMBRAY, M. The French Shale Industry. Oil Eng. Finance, *2,* 477 (1922); C. A., *17,* 3096.
General information of bituminous shales and their mineral and organic constituents given. Discusses French shale industry retorts used, methods of distillation, $(NH_4)_2SO_4$ manufacture, refining, characteristics of products, and their uses, and present and future prospects for industry in France.

896—CRONSHAW, H. B. Oil Shales. London: John Murray, Albemarle St.; 80 pp.; C. A. *16,* 1503 (1922).
Monograph prepared under direction of Mineral Resource Committee of Imperial Institute. Description of principal known areas offering promise as future shale oil fields. Guide to oil shale fields of world.

897—CUNNINGHAM-CRAIG, E. H. The Oil Shale of Esthonia. Engineering, *113,* 624 (1922); C. A., *16,* 2777.
Lecture before Institute of Petroleum Technologists. Esthonia shale (also known as kukersite) is oldest and richest shale being worked, except for torbanites, which are frequently classed with cannel coal. Oil shales up to 8 ft. thick are quarried in open workings. Layers of shale are separated by bands of limestone, which is crumbly, much like sandstone. About 50% of so-called shale is calcite debris of fossil trilobites and brachiopods. This shale believed to be example of inspissated petroleum absorbed by colloidal inorganic matter. As high as 90 gals. of petroleum obtained from ton of this shale. Probable future of oil-shale industry discussed.

898—CUNNINGHAM-CRAIG, E. H. The Oil Shales of Esthonia. Petroleum Times, *7*, 673, 697 (1922); C. A., *16*, 3198.
Mineral matter in shale has the composition of Fuller's earth and limestone. Yield of oil 90 gals. per ton. Distillation does not begin at low temperatures but when it does begin is rapid and completed under 450° C. Does not believe distillation of this shale in vertical retort to be practical. Different theories as to origin are discussed. Estimates 1000 million tons of shale in these deposits, yielding from 70 to 80 gals. per ton of 0.92 to 0.93 sp. gr. oil containing little S and easily refined. Solid paraffin will be almost entirely absent.

899—CUNNINGHAM-CRAIG, E. H. The Development of Oil Shales and Torbanites. Oil Eng. Finance, *2*, 478-82 (1922); C. A., *17*, 3096.
Oil shale an absorption product due to so-called argillaceous deposits of petroleum formed in adjacent parent oil fields. Torbanites are essentially products of carbonaceous phase and are, broadly speaking, a special form of cannel coal developed in situ. Their advantages over oil shale are: (1) They yield their oil at a lower temperature; (2) they give a higher yield (80-100 gals. per ton for some French torbanites); (3) the oil is of better quality, having less refining loss and yielding more valuable refined products. Torbanites are gels formed in situ by combination of petroleum as it forms in minute globules with colloidal mineral matter. In contrast, oil shale is a deposit which has absorbed and held oil obtained from elsewhere, losing a portion of lighter and more valuable oils, but relatively gaining in N_2 content. A torbanite, on the other hand, is a petroleum deposit formed in situ, very rich in all forms of oil, and so much so as possibly to make it uneconomic to extract the $(NH_4)_2SO_4$. Discussion of occurrence of shale deposits, prospects of exploitation and methods of retorting given.

900—CROUSE, C. A. Oil Shales of Kentucky. Combustion, p. 237 (1922); Chem. Age (N.Y.), *30*, 353 (1922).
Kentucky has enormous oil shale deposits yielding 15 gals. oil per ton shale. Amenable to steam shovel mining there is said to be 90,000,000,000 tons of such shale. Every other factor except high oil yield favors Kentucky as center of large shale oil industry.

901—DAY, DAVID T. Petroleum and Natural Gas. Mineral Ind., *31*, 499-552 (1922); C. A., *17*, 3780.
Data on markets, trade, and the world's production conditions in various fields discussed and world's oil-shale deposits considered.

902—DVORKOVITZ, PAUL. Desulphurizing Shale Oils. Petroleum Times, *8*, 380 (1922).
Letter to the author of "Sulfur in Shale Oils," Petroleum Times, *8*, 330 (1922). Dvorkovitz suggests treatment of shale before distillation to hold sulfur in the ash as only means of eliminating sulfur.

903—ESTHONIAN CONSULATE, New York City. Esthonian Oil Shale as Fuel. Commerce Reports, U. S. Dept. Commerce. Dec. 4 (1922), p. 600.
Cost of oil shale as fuel power approximately half that of wood and turf. Oil shale is being used as a fuel by several railways and it is proposed to use it as fuel for ships.

904—FELL, D. A. Oil Shale and a Future American Industry. Petroleum Times, *7*, 417 (1922).
Appeal for the recognition of nature's supply of oil shale as potential resource of oil and short description of geology of shale together with its properties and method of shale oil production.

905—FELL, D. A. Nat. Petroleum News, *14*, No. 18, 89, 90, 93 (1922); C. A., *16*, 2219.
Fell process, shale crushed in gyratory rock breakers and delivered to vertical retorts at top hopper; it works through into bottom hopper by gravity. Steam introduced into retort at point where shale attains highest temperature. Three products obtained: crude oil, crude naphtha recovered by means of scrubber towers and NH_3.

906—FRANKS, A. J. Chemical Engineering and Economics in Shale Oil

Production. Petroleum World, *19*, 12-4 (1922); C. A., *16*, 1313.
The problems are discussed.

907—FRANKS, A. J., and GOODIER, B. D. Preliminary Study of the Organic Matter of Colorado Oil Shales. Quarterly, Colo. School of Mines, *17*, No. 4, Oct. (1922).
By successive heating at 300° to 350° C. for periods of eight hours and extractions, extracted heavy bitumen without producing any oil. Total time of heating was 129 hours to complete process of transformation from kerogen to this semi-solid bitumen, the oil forming constituent of kerogen. Concludes that this decomposition not a depolymerization nor does it take place at definite temperature, but within wide range of temperatures. Rate of decomposition is much greater at higher temperatures. Bitumens produced at different temperatures were apparently not of same composition. Oil forming part of the kerogen is a complex mixture.

908—FREEMAN, NAT. H. Internally Heated Retorts. Petroleum Times, *8*, 86 (1922); C. A., *16*, 3198.
Internally heated retorts for shale industry are not practical from theoretical standpoint.

909—FREY, WILLY, and FABER, ALFRED. Production of Benzine and Lubricating Oil from Coal and Crude Oils. Chem. Ztg., *46*, 377-9 (1922); C. A., *16*, 2403.
The cracking process patented by Blumner (German patents 338,846 and 340,-991; also several pending applications) is recommended for making motor fuel and lubricant from lignite tar, producer tar or shale oil produced in Germany, or from imported low-grade petroleum products such as gas oil or Mexican crude oil. The oil sprayed into lower section of decomposition autoclave from which it passes to superimposed chamber filled with Raschig rings and surrounded by bath of molten metal. Construction is such that rapid circulation of molten metal along the wall exposed to furnace is insured. The apparatus is small, but has large daily capacity. The following yields are claimed: from lignite producer tar: 30.2% benzine, 34.4% lubricating oil and paraffin, 16% asphalt, 16.9% gas and loss and 2.5% H_2O; from shale oil (Middle Germany): 32.5% benzine, 31.0% lubricating oil and paraffin, 15.4% asphalt, 20.5% gas and loss, and 0.5% H_2O.

911—FYLEMAN, ERNEST. Separation of Adherent Oil or Bitumen from Rock. J. So. Chem. Ind., *41*, 14-16T (1922).
Tar sands of Alberta, underlying many square miles adjacent to the Athabasca River, constitute one of world's largest potential oil supplies. Oil is asphaltic in nature, and present to extent of 15 to 25 Imperial gallons per long ton. Oil removed by heating sand to 80° C. and gently agitating with one-tenth per cent solution of sodium carbonate. Recovery accomplished at relatively low cost.

912—GAVIN, MARTIN J. Analytical distillations of typical Shale Oils. Bur. of Mines, Rept. of Investigations, 2332, 12 pp. (1922); Eng. Min. J. Press, *113*, 683-4; Petroleum World, *19*, No. 260, 181 (1922); C. A., *16*, 2024.
Oil shale studies of Bureau of Mines conducted in coöperation with State of Colorado and University of Utah. Typical oil shales from different localities were retorted in carefully regulated retorts of different types. Different shales gave different products under like conditions and the same shale gave different products under different conditions. Main problem to get a maximum yield of best product. Effect of distilling crude oil after retorting shale described and characteristics of various shales summarized in tabulated form.

913—GAVIN, M. J. Oil Shale—Historical, Technical and Economic Study. Bur. Mines, Bull. No. 210, 201 pp. (1922); C. A., *17*, 1711. See Abs. 1086 for 1924 revision.
Descriptions given of foreign deposits of oil shale and of U. S. deposits. Nature and origin of oil shales, including analyses of mineral content, and nature of destructive distillation of oil shale discussed. History of oil shale industry outlined and development of Scotch industry given in detail. Present status of industry and economic importance to the U. S. discussed. Types of retorts used in U. S. given. Problems of the

industry outlined fully, with suggestions for solving some of them. Other chapters are: The Future of the Oil Shale Industry in the U. S., Estimate of Costs and Profits in the Industry, Sampling and Assaying of Oil Shale, Physical and Chemical Data on Colo. Oil Shale. This is probably the best and fullest description of the shale oil industry published before 1923.

914—GAVIN, M. J., and AYDELOTTE, J. T. Solubility of Oil Shales in Solvents for Petroleum. Bur. Mines, Repts. of Investigations, No. 2313, 3 pp. (1922); C. A., *16*, 1500.

Samples ground to pass 20-mesh, and all material passing 60-mesh rejected. Extracts by CCl_4, CS_2, Me_2CO, Et_2O, C_6H_6, and $CHCl_3$ were similar in appearance, being dark brown or black, and more or less fluid. Not appreciably affected by cold conc. H_2SO_4 or HNO_3, insoluble in cold and slightly soluble in hot alcohol. Percentages extracted varied from traces to 10.98% of weight of shale, and up to 55.8% of distillation yield. Largest amounts were extracted by acetone and chloroform. Per cent extraction by solvents is no criterion of distillation yield.

915—GAULT, H., and BOISSELET, L. Contributions from the Petroleum Laboratory of the Univ. of Strassburg. Mat. Grasses, *14*, 6030 (1922).

A distillation analysis of bitumen from Auvergne is given. Certain Esthonian schists from Kukers, Kochtel and Vanamoise gave 10 to 35% of crude oil by distillation.

916—GUISELIN, A. Lignites and Bituminous Shales. Chimie et industrie, *7*, 1225-9 (1922); C. A., *16*, 3378.

Plea for taking of reliable inventory of French resources and for their proper utilization.

917—GUTHRIE, V. B. Fleming Process is Found Successful by Sterling O. & R. Co. Nat. Petroleum News, June 28 (1922), p. 23.

Time cycle of running given and yield of light distillate, heavy distillate, still bottoms, coke and loss in percentage. 75% of light distillate below 419° F.

918—GWOSDOV, S. P., and NAGOZHOV, N. N. The Nature of Hydrocarbons produced by the Destructive Distillation of Weimarn Oil Shales. Petroleum Shale J. (Russia), *111*, 194 (1922); J. Inst. Petroleum Tech., *9*, 157-8A; C. A., *17*, 3601.

Material to be tested was from light fractions (below 170° C.), obtained by destructive distillation at low temperatures and treatment with weak acids and alkalies. Initial material consisting chiefly of unsaturated compounds, was separated into 2° C. fractions. From results of densometric, refractometric and cryoscopic tests to which individual fractions were subjected Gwosdov and Nagozhov conclude that some of essential constituents of shale oil are hydrocarbons of the dihydro- and the tetrahydro-benzene series.

919—HAAS, PAULINE. Monograph of the Shale Oils of the German lias E. Braunkohle, *20*, 673-81, 726-31, 741-8 (1922); Dissertation Heidelberg; C. A., *16*, 1860.

Geology, economic value and historical development of the industry.

921—HENTZE, E. Oil Shale. Petroleum Z., *18*, 1233-47 (1922); C. A., *17*, 465.

Shales are classified as primary shales, those in which bitumen occurs, and secondary shales as those from which bitumen has migrated. Esthonian shales are primary shales. Origin and geological formation of Esthonian shales discussed. Kukersite often runs high as 75% bitumen and 15 to 16% oil. Low temperature distillation gave best results in oil yield, temperature limits being 300 to 360° C. Use of shale for direct burning on the grate and for retorting discussed.

922—HENTZE, E. The Possibility of Isolating Bitumen in its Original Condition from Bituminous Shales. Z. angew. Chem., *35*, 330-1 (1922); cf. C. A., *16*, 2598; C. A., *17*, 1325.

Separation of bitumen and mineral constituents of a diatomaceous earth and of shale, kukersite, attempted in following way. About 2 kg. of each mineral was treated for 14 days with dilute HCl at ordinary temperature. After Ca ion and Fe ion removed as thoroughly as possible a similar treatment of residue with dilute HF and then with 40% HF followed. Latter treatment required

4 weeks for kukersite and 2 weeks for the earth. Deep olive-green, pasty residue obtained from the earth. It dried quickly and could then be rubbed to a powder. Removal of mineral constituents was, however, incomplete in each case. Residues accordingly extracted with $CHCl_3$, the best solvent for these products. After evaporation of $CHCl_3$, a stiff, plastic, olive-green residue remained from diatomaceous earth sample. The extraction from kukersite dark brown and also plastic. Not all the bitumen was recovered; 58 g. of possible 80 g. was recovery from kukersite. Portions of these bitumens were mixed with silica or with clay and lime (same percentages as mineral constituents in original) and distilled from a glass retort. Percentages of volatile products obtained smaller than from minerals themselves. Decrease was 1% for diatomaceous earth and 5% for kukersite. Likewise, the percentages of low-boiling constituents recoverable from tars were increased. Coke from recovered bitumen had higher per cent of C than that from mineral itself. These differences indicate that original bitumen not isolated by process used, and changes attributed to polymerization. The "cracking" of polymers gives rise to increased percentages of low-boiling products. Possibility of separating bitumen by electro-osmosis good. Microscopical examination shales shows that bitumen associated with clay, and latter functions as protective colloid.

923—HOLMBERG, BROR. Researches on Shale. Inginiorvetenskapens Akademiens Handlingar, *6*, 88 pp. (1922); Chem. Zentr., *1922*, IV, 82; C. A., *17*, 2777.

Monograph on dry-distilled Swedish shale oil, especially cement-shale. Benzine from Schonen, behavior of which toward reagents described, with extraction experiments on alum shale by various methods and action of heat on shale bitumen.

924—HOLMBERG, BROR. Bituminous Shale. Tek. Tid., *52*, 563-5, 609-11 (1922).

Address presenting data on examination of samples of shale, coal and other mineral deposits of Sweden.

925—HOSKIN, A. J. Aspects of Colorado's Oil Shale Industry. Proc. Colo. Sci. Soc., *11*, 295-328 (1922); C. A., *16*, 4334.

Comprehensive review of possibilities of production of oil from Green River shales of Utah and Colorado, with description of these geologic formations. Mining costs, probable cost of construction of plants and annual depreciation estimated. Eleven processes considered as most promising possibilities for retorting described and discussed in detail.

926—HUTCHINS, T. W. STAINER. The Fusion Rotary Retort. Petroleum Times, *8*, 823 (1922).

Description of this retort with diagrams and results of test runs on different materials.

927—INGS, G. A. Tar Sand Experiments in the Athabasca Field. Oil & Gas J., *21*, 92 (1922).

Crude oil can be produced from these sands at cost of 35¢ per barrel. Oil will average 14% gasoline, 45% kerosene and 5% residue (bitumen chiefly). Extraction or distillation on ground claimed to be feasible.

928—JENSON, J. B. Shaloilogy and Oil Shale Nomenclature. Petroleum Times, *7*, 95-7 (1922); Chem. Met. Eng., *26*, 509-12 (1922); C. A., *16*, 1313.

Plea for development of scientific vocabulary for oil shale industry, with recommendations.

929—JONES, C. L. The Problems of the American Shale Oil Industry. Chem. Met. Eng., *26*, 546-53 (1922); C. A., *16*, 1500.

Outline of present state of our knowledge in various divisions of field of oil shale technology, with suggestions for future investigations. Study of nature of kerogen may be attacked first by means of morphology, microscopy and physical characteristics. Separation from inorganic material may be followed by study of its chemical properties. Several methods for separation as well as reagents and solvents for ascertaining its chemical nature suggested.

931—KARRICK, L. C. Factors affecting Products from Destructive Dis-

tillation of Oil Shales. Repts. Investigations, Bur. Mines, No. 2324, 5 pp. (1922); C. A., *16*, 1501.
Decomposition of kerogen on pyrolysis influenced by physical properties of mineral portion of shale. Even distribution of heat complicated by difference in thermal conductivity of kerogen and mineral matter. Dehydration of some salts, e.g., $CaSO_4.2H_2O$, and decomposition of carbonates and sulfides take place at retort temperature and gases formed may alter course of decomposition of the kerogen. Pressure may develop in interior of pieces of shale, owing to resistance offered to escape of vapors. Vapors then heated to higher temperature than would otherwise be the case. Each shale must be studied as special problem, in order to establish effects of temperature, rate of applying heat, presence of gases, etc., upon character of products formed. Devonian shales of eastern U. S. contain spores largely, while those of Green River district contain, in addition, resinic and cellulosic materials, as do some cannel coals and slates of eastern U. S. Much of difference in products obtained from these various materials in given process of pyrolysis due to difference in mineral substances. Temperature lag from outside to inside of charge in retort illustrated and discussed briefly. Fine grinding suggested as important subject of research.

932—KOGERMAN, P. N. The Chemical Composition of Esthonian Middle-Ordovician Oil-Bearing Mineral, Kukersite. Private publication by the author, Dorpat, 1922, 25 pp.; C. A., *16*, 4336.
Two oil-bearing minerals, kukersite and dictyonema shale, form two layers, Cambrian and Middle-Ordovician strata in north of Esthonia. Kukersite more important, deposits being 1500 million tons. Water content varies with location of seam and with hygroscopic condition of air at quarries. Average value 35%, although air-dry samples rarely exceed 7%. Ash content varies between 20 and 50%. No oils extracted by organic solvents. At 600° C. largest yields of oil obtained, about 75 gals. per ton. Crude oil dark brownish with slight greenish fluorescence, sp. gr. 0.939. Very little $(NH_4)_2SO_4$ is obtained from kukersite. Crude tar may be used directly as fuel. Paraffin content low. Acid numbers of fractions from a vacuum distillation (30-50 min.) vary from 4.0 to 7.5.

933—MacKENZIE, J. C. D. The Turner Internally Heated Retort. Petroleum Times, July 1, 1922, 15; C. A., *16*, 3201.
Description of this apparatus for distilling of shales.

934—MARCUSSON, J., and PICARD, M. The Composition of Peat and Shale Tar. Petroleum Z., *18*, 637-8 (1922); C. A., *16*, 3379.
Peat tar digested with ether gave black residue composed of oxy-acids and their esters, together with salts of Fe and Ca. Shale tars tested in same way gave 16-22% fatty and oxy acids, including those present as Ca salts, and 5% of basic substances.

935—McCANN, W. S. Recent Experimental Work in the Rosevale (Baltimore, N. B.) Oil Shale Area. Can. Dept. Mines, Memoir, *129*, 56-60 (1922); C. A., *17*, 1325.
Plant used, though complete in itself, a unit of possible future plant of much greater capacity. Designed to treat oil shales by Wallace process. Charge of about 1000 lbs. shale heated in retort for 3 hrs. at approximately 730° and steam injected into retort during process. Volatile constituents withdrawn by vacuum from inner duct of retort to water-cooled condensers where oil is condensed and gases carried to ammonia scrubber plant. Comparison of yields by Wallace retort with Scotch tube methods gave 2.5 gals. in favor of former. Working data of plant given.

936—McKEE, R. H. Gasoline from Oil Shale. Chem. Age (N. Y.), *30*, 1-4 (1922); C. A., *16*, 1147.
Green River shales of Colorado, Utah and Nevada alone, in known deposits, can furnish eight times total amount of well-petroleum so far produced in U. S. Decomposition of oil shale is endothermic, about 450 cal. being absorbed per gram of oil and gas produced. Primary decomposition product a heavy bitumen, oil formed as secondary cracking product. Decomposition temperature definite, 400-410° C. Gasoline from shale oil by

ordinary cracking processes will be colored, malodorous, and inclined to carbonize. McAfee process will give stable, water-white gasoline of pleasant odor but process more expensive. Scottish retort, primarily designed for recovery of NH_3 not best adapted to handling American shales, which require a retort designed primarily for recovery of oil.

937—McKEE, R. H. Shale Oil. J. Ind. & Eng. Chem., *14*, 847 (1922); Petroleum Times, *8*, No. 197, 581 (1922).
Discusses gasoline and petroleum situation. Extensive experimental work on shale as source of oil being carried out by the Colorado School of Mines and also by U. S. Bureau of Mines. Catlin Shale Products Co. of Elko, Nev., has apparently solved primary retorting problems and is operating. Stages in decomposition of bitumen described. Excellent light lubricant obtained from shale oil. Moderate temperature retorting produces up to 20% nitrogenous bases which will in future compete with nitrogen bases of coal tar.

938—MITZAKIS, MARCEL. The Oil Encyclopedia. London. See Engineering, *113*, 499 (1922) for review.
Devotes some space to discussion of shale oil.

939—NARBUTT, J. The Isolation of Organic Substances in Esthonian Oil Shales. Z. angew. Chem., *35*, 238-9 (1922); C. A., *16*, 2598.
Powdered shale was evaporated to dryness with HCl, extracted in a Soxhlet apparatus with MeOH until no reaction with $(NH_4)_2S$ occurred. The residue was then dried, evaporated with HF and later repeatedly with HCl. The mixture was washed and again extracted with MeOH. The organic matter (about one-third the original material) was obtained quantitatively. It is a dark brown powder with density less than 1, yields 2.5% of ash (chiefly Fe_2O_3), is partly soluble in aromatic hydrocarbons like naphthalene and phenanthrene at 300-330°, with partial decomposition, and, when heated alone to 300-350°, decomposes into a clear brown oil and a carbonaceous residue, and evolves a gas containing H_2S.

941—NORMAN, J. T. Recent Oil Shale Developments. Petroleum Times, *7*, 510 (1922); C. A., *16*, 2219.
Esthonian fields are briefly described. Attention is called to inevitable decline of well production of crude oil.

942—REEVES, J. R. The New Albany Shales of Indiana. Bur. Mines, Repts. Investigations, No. 2390, 8 pp. (1922); C. A., *17*, 205.
Principal oil shale of Indiana known as New Albany shale. Normal thickness of shale beds about 100 ft. Microscopic examination of thin sections of shale reveals resinous appearing spores and spore cases. Typical New Albany shale contained moisture 0.82, volatile matter 15.86, fixed C 5.54, ash 77.78, total S 4.36%. The shale yields 6 to 14 gals. per ton of oil of d. 0.940. Viscosity at 130° F. 43. Per cent tops 47.6 (distilling up to 275° C.). N content 0.5%, equal to 42.5 lbs. of $(NH_4)_2SO_4$ per ton. Potash content too low to be of commercial value.

943—REEVES, J. R. A Section through the New Albany Shale. Bur. of Mines, Repts. of Investigations, No. 2425, 3 pp. (1922); C. A., *17*, 1325.
A boring made in Clark County, Indiana, and core divided into 31 sections of 3 ft. each. Yield of oil for upper 50 ft., 11.6 gals. per ton; between 50 and 60 ft., yield low; while from 60 to 98 ft. it averages 7.0 gals. per ton. That oil-forming material of shale is of same composition throughout its depth is shown by small variation in sp. gr., and amount of tops from crude oil.

944—RINNE, E. Oil Shales. Pt. II. Fuel Shales and Shale Oil Recovery in Esthonia. Petroleum Z., *18*, 1441-4 (1922); C. A., *17*, 3098.
General review of shale deposits of Esthonia, giving analyses of various samples and of shale oils distilled therefrom.

945—RUSSELL, W. C. The Mining of Oil Shales. Railroad Red Book, *39*, 1051-5 (1922); C. A., *17*, 629.
Russell describes Colorado shale deposits and discusses methods to be employed in mining same.

946—SOLLNER, MAX. Gasification of Oil Shales at the Innsbruck Gas Plant. Gas u. Wasserfach, *65*, 514-6; Z. Ver. Gas Wasserfach, *62*, 31-4, 35-8 (1922); C. A., *17*, 201.
Shale of poor quality consisting of clay 30-40%, limestone 30-40%, organic material 3-20% and small amounts of S, N, P, alkalies, silicates, etc. By gasification, it yields 15-20 cu. m. of 3000 cal. gas per 100 kg., 0.5 kg. tar, 80-85% residue, remainder being coke for firing. Residue suitable for making artificial building stone by further treatment in a lime kiln. A by-product which has been made subject of patent is CaS for use as a dehairing agent in leather manufacture.

947—SOUVIRON, L., and RANZAULES, M. The Occurrences of Bituminous Shale in the Communes of Ronda, Alpandeire and Cortes de la Frontera Malaga. Bol. ofic. minas met., *5*, No. 65, 29-68 (1922); Rev. Geol., *4*, 793; C. A., *18*, 804.
The bituminous shale has a thickness of 20 cm. to 2 m. Outcrops are numerous. Mean content of oil 5%.

948—STARR, CHAS. C. Sampling of Oil Shale. Eng. Mining J.-Press, *113*, 873-7 (1922); C. A., *16*, 2403.
On account of low value of material, accuracy in sampling of oil shale important. Sampling may be by diamond drill or careful surface sampling of all strata of possible commercial value. Surface sampling should be accompanied by careful study of strata to determine uniformity or lack of uniformity of oil content and other characteristics. If weathered outcrop cleaned off, leaving fresh appearing shale, strata of good or medium shale may be sampled directly on surface. Upper strata of rich shales variable in surface structure and oil content. Sampling from this type shale should be in numerous places to obtain true value. Average error of properly taken surface samples about 2.5%.

949—STARR, CHAS. Oil Shale from a Mining Viewpoint. Petroleum Times, *8*, No. 183, 73 (1922).
Mining shale not comparable to mining coal. Before opening large shale mine certain factors must be considered. Location of mine entrance, reduction plant, waste dumps, etc., are discussed. Methods and machinery will be developed as a result of experience with different type shales.

951—SWINNERTON, A. A. Treatment of Oil Shale from New Brunswick by the Ryan Oil Digestion Process. Can. Dept. Mines, Summary Rept., 1922, No. 605, 210-8 (1922); C. A., *18*, 1563.
Several runs made on a laboratory scale resulted in no definite conclusions, owing mainly to excessive handling losses, principally in centrifuging operation. Process is not recommended for treating New Brunswick shales.

952—TAKAHASHI, JUNICHI. Silicous Shales in the Oil Measures of Japan. J. Geol. Soc. Tokyo, *29*, 17-27 (1922); Japan J. Geol. Geog., *1*, 19A; C. A., *17*, 2696.
The chemical and petrographical examination of the silicous shales which constitute the lower part of the Japanese oil measures is described.

953—TAKAHASHI, JUNICHI. Microglobulites in the Oil-Measure Shales of Japan. J. Geol. Soc. Tokyo, *29*, 56-61 (1922); Japan J. Geol. Geog., *1*, 19-20A; C. A., *17*, 2696.
Numerous fine globules of yellowish or brownish color, 0.06-0.002 mm. in diameter in oil-measure shales have been variously referred to as resin, spores, bitumen, etc. Examination under the metallographic microscope shows that they are composed of radiating fibers of Fe sulfide. This suggests that the shales belong to organogenetic rocks formed under anaerobic conditions.

954—VARLEY, THOMAS. Bureau of Mines Investigate Gold in Oil Shales and its Possible Recovery. Bur. of Mines, Repts. of Investigations, No. 2413, 10 pp. (1922); C. A., *17*, 714.
Gold in oil shales can be determined accurately by the ordinary fire-assay method. Only small percentage of total gold recovered by cyanidation or chlorination treatments, which would therefore not be feasible commercially even in the presence of commercial quantities. In the samples of shale examined the gold assayed no more than 50¢ a ton, and is of no commercial value.

955—VON ANTROPOFF, A. The Oil Shale Development and the Oil Shale Industry in Esthonia. Z. angew. Chem., *35*, 647-51 (1922); C. A., *17*, 872.

Location of deposits given. Relation established between geological formations of Esthonia and shale deposits. Kukerssche shale is found in layers interstratified with limestone. Shale is of animal origin, as shells and fossils are found in it. Deposit contains 800 sq. km. and is estimated to contain 1½ billion tons of shale. The shale has d. 1.2-1.6 and chocolate brown color when moist, drying to a light gray. Material easily lighted with match and burns with bright sooty flame. If powdered and atomized into fire it burns readily. The air-dried shale contains bitumen 49.8%. The volatile content is 56.7%, coke 4.8% and ash 38.5%. Shale is utilized for fuel, cement, gas and oil products. Its ash content is applicable as one of the constituents of cement. It yields 300 cu. m. gas per ton with 3.5% tar. The use for gas manufacture has not been profitable. Since August, 1921, a Pintsch retort of 9 tons capacity per 24 hours has proven successful and two more are being installed. The distillation is by means of internal heat, preheated flue gases supplied from distilling chamber from spent shale being used. Vapors are cooled and condensed and the remaining gas is used for fuel. No extra energy beyond that derived from the shale needed. The amount of oil is 20% by weight. Sp. gr. of crude oil is 1.01, viscosity (Engler) 5.5 at 50°, heat 9700 kg. cal. No paraffin is present in the oil.

956—VON GROELING, A. E. The Newer Methods of Shale Oil Extraction. Petroleum Z., *18*, 487-493, 593-545 (1922); C. A., *16*, 3198.

Various processes in use for the extraction of shale oil described and their merits discussed. American digestion method described and its superiority over Scottish process in retorting Colorado shales is emphasized. Suggested that the use of superheated steam would give better results.

957—VON ZUR MUHLEN, L. Oil Shales. Pt. III. The Distribution of Oil Shales in the Eastern Part of European Russia. Petroleum Z., *18*, 1477-82 (1922); C. A., *17*, 1134.

General description of these deposits, with analyses. Principal deposits lie along Volga and between it and Ural Rivers, richest and most extensive being Steppes of Obschi Syrt. Economic conditions bearing on development discussed. Short bibliography appended.

958—WINCHESTER, DEAN E. Factors Influencing the Value of Oil Shale Lands. Petroleum Times, *8*, 413 and 655 (1922).

General discussion as to what lands are valuable for their oil shale. Classification of oil shale lands in tabular form included. Oil shales are variable in physical and chemical characteristics. Occur mostly in Tertiary in Rocky Mountain region. Valuable oil shales occur throughout the total thickness of Green River formation. Value of any oil shale property depends upon many factors, i.e., richness, geographical location, mining and reduction facilities.

959—WOBLING. A New Apparatus for Distillation Analysis and Experiments with Oil Shale. Braunkohle, *21*, 453-4 (1922); C. A., *17*, 206.

Inclined porcelain tubular retort in an electric oven found most effective apparatus for distilling oil shale on an experimental scale. By distilling 400 g. of shale for 3-4 hrs. with 2 kw.-hrs. power consumption, yield of tar obtained greatly exceeding that from any other type of apparatus. The water and tar distilled over were condensed in a modified Pelicot condenser, and the gases were freed from H_2S and CO_2 by $Pb(OAc)_2$ and KOH. Oil shales from various localities showed great differences in tar, the consistency varying from thin liquid to solid. Light oil contents in general low, whereas the oils from 150° to 250° reached 30-40%, with thick oils from distillation in vacuo up to 300° approximately same, and pitch residue of 10-20%. Towards 300° decomposition became considerable, and distillate became deep red. Content of alkali-soluble constituents only about 5%. Treatment with H_2SO_4 caused considerable resinification. By preliminary removal of the basic compounds with dilute H_3PO_4, this did not occur. The S content varied greatly. Even with long heating with Zn dust, the per cent S could not be reduced,

and distillation of the shale with Fe failed to decompose the organic S compounds. High mercurization and I nos. indicated considerable per cent of unsaturated compounds, differentiating shale tar fundamentally from petroleum.

961—WRIGHT, W. J. Geology of the Moncton Map-Area. Can. Dept. Mines, Memoir, No. 129, 60 pp. (1922); C. A., *17*, 1203.
Geological description uses 28 pages. Remainder of paper devoted to oil shales of this area and Nova Scotia. Analyses of 43 samples of 20 lbs. each of shales from Albert County, New Brunswick, are tabulated. Excluding 2 barren samples, ash content ranges from 63.0 to 83.5%; B.t.u. per lb., 630 to 4200, average about 1600; N, 0.21 to 0.71%; yield of oil per ton, 4.8 to 32.2 Imp. gals.; yield of gas per ton, 380 to 1485 cu. ft. The B.t.u. per cu. ft. of the gas ranged from 280 to 770. Fifty tons of shale from the Baltimore, N. B., area sent to Scotland and retorted by the Pumpherston Oil Co. The results of this test were: Oil per ton, 40.0 Imp. gals. with a sp. gr. of 0.92; $(NH_4)_2SO_4$, 77.0 lbs. per ton. Five other samples from this area gave from 39.0 to 56.8 Imp. gals. of oil and 30.5 to 112.2 lbs. of $(NH_4)_2SO_4$ per ton. Five samples of shale from New Glasgow, N. S., gave from 2.3 to 14.7 Imp. gals. oil per ton.

962—ALDERSON, V. C. A Comprehensive Survey. American Mining Congress Report (Milwaukee Meeting), 1923; Mining Congress J., Oct. (1923), 383-385.

963—ALDERSON, V. C. Oil Shale—A General Survey. Mountain State Mineral Age, 13-14, Sept. (1923).

964—ALDERSON, V. C. Oil Shale. A Résumé for 1922. Railroad Red Book, *40*, No. 1, 9-22 (1923); C. A., *17*, 1134.

965—ANON. Oil from South African Shale. Petroleum Times, *9*, 251 (1923); C. A., *17*, 1546 (1923).
Lamplough-Harper process of shale distillation said to yield distillate containing no permanent gases. Crushed shale fed into vertical retort through hopper and does not come into contact directly with fireheated surfaces of retort. From retorts vapors pass into fractionating and scrubbing tower where crude oil separated into light fraction, lubricating oil, gear and axle greases, wax and bituminous residue suitable for road construction. Lighter fractions (b. 60-300°) rise into upper part of tower and thence into special apparatus in which motor spirit, kerosene and substitute for paint oil formed. Yield of 49.4 gals. crude oil per ton shale obtained, yielding 40% of motor spirit.

966—ANON. Chilian Oil Shale. Oil Eng. & Finance, *3*, 253-5 (1923); C. A., *17*, 1711 (1923).
Analysis of 19 samples of shale from near Pular, Chile, showed oil content of 12-14.5%. Oil distilled has sp. gr. of 0.934 which sinks to 0.887 on standing. Distillation tests show 8% below 100°, 12% between 100° and 150°, 18% between 150° and 200°, 20% between 200° and 250°, 38% between 250° and 300° and 4% of a pitch residue. On mixing all fractions below 200° and redistilling, over CuO, a pale yellow oil of fragrant odor obtained which did not deteriorate in 3 months. S in original oil less than 0.25%. Paraffin content about 10-12%.

967—ANON. New Rotary Shale Retort. Chem. Age (N. Y.), *31*, 9-10 (1923); C. A., *17*, 1712 (1923).
Retort designed by J. B. Newbery described. 5-ton retort gave 3¼ bbls. oil per day from shale with oil content of 27⅝ gals. per ton. Retort consists of number of shelves arranged one above the other; heated shale carried by arms through complete revolution on each shelf and then falls through slot to next shelf. Heating is through center flue.

968—ANON. Retorting Experiments on Norfolk Shale. Petroleum Times, *9*, 729-30 (1923); C. A., *17*, 2498 (1923).
Brief description of 10 experiments which have been carried out with different types of shale retorts at Setch, near King's Lane, England. Scotch retort appeared to give best results.

969—ANON. Progress of Oil Shale Retort in the United States. Petroleum Times, 418, Sept. 22 (1923).

Describes different retorts invented in the United States which have promise of being successful.

971—BAILEY, E. M. Scotch Bituminous Shales. Chimie et Ind., *Special No.*, 423-8, May (1923); C. A., *17*, 3246.
A description of distillation process and purification of oil.

972—BATTLE, JOHN B. Shale Oils. Industrial Oil Engineering, 157-163 (1923).
Devotes Section 4b of this book, "Industrial Oil Engineering," to shale oils. Location of shales, products obtained, future of American shale oil industry, general résumé of subject of shale oil.

973—BERTHELOT, CH. Modern Furnaces for the Distillation of Bituminous Shales. Chimie et Ind., *Special No.*, 439-42, May (1923); C. A., *17*, 3246.
Description of Scottish retort, Fischer rotary furnace, and Salerni horizontal furnace.

974—BORDAS, F. Terminology and Physical and Chemical Characteristics of Petroleum Products. Chimie et Ind., *Special No.*, 89-94, May (1923); C. A., *17*, 3094.
Discussion of necessity of precise and clear definitions, with list of commercial products derived from Pechelbronn petroleum, commercial benzene and tar products, and commercial products from Autun bituminous shale products, and their chief properties.

975—BOTKIN, C. W., and BOYD, R. W. Petroleum Age, *11*, No. 3, 56-62 (1923); C. A., *17*, 1134.
Decomposition attending distillation of oil shales lowers percentage of N in fractions, but does not materially change I numbers. I numbers of acid-soluble oil decrease very rapidly with increase in gravity and boiling point. Decomposition increases N content of acid-soluble oil and causes large increase in I number of light fractions which contain highest amount of "new" saturates. I number of acid-soluble portion of heavy fractions similar to olefins of equal boiling point. Light unsaturated acid-soluble oils from shale contain over 1% of N. It is suggested that compounds similar to these may make up gum-forming constituent of gasoline and that large ratio of I number to H_2SO_4 absorption number may serve as indication of presence of these constituents.

976—BOTKIN, C. W. Thermal Decomposition of Shale Oils under Pressure. Railroad Red Book, *40*, 887-92 (1923); C. A., *18*, 164.
Paraffin base and asphaltic base shale oil heated at about 320° under pressure of gases produced by decomposition gave 87 and 81%, respectively, of oils recovered, containing, respectively, 11 and 26% of oil distilling to 150°, an increase in this fraction of 10 and 19.5%. Per cent of saturates in light fraction from cracked oils 75 and 64%, respectively, an increase of about 25%. Mixed base shale oil decomposed under conditions similar to Burton cracking process, yielding 65.4% oil by weight, 23.9% of which distilled below 150° and 56% below 210°, an increase of 40% in last-named fraction. Per cent of saturates in this fraction 56, or 12% higher than same fraction of original crude oil. Thermal decomposition of shale oils under increased pressures, therefore, very materially increases yield of crude motor fuel and also at same time improves refining qualities of fraction much beyond that of similar fractions distilled at atmospheric pressure.

977—BREUER, P. K., and BROCHE, HANS. The Presence of an Oil Shale Rich in Tar in Germany. Brennstoff-Chem., *4*, 200-1 (1923); C. A., *18*, 324.
Shale exists in Saxony which on distillation from aluminum distilling apparatus gave primary tar 68.9, residue 23.6 and primary gas 7.5%. Tar contained phenol 11.6, lubricating oils 35.8 and solid paraffins 22.4%.

978—BRUNSCHWEIG. Brief Description of the French Bituminous Shales. Chimie et Ind., *Special No.*, 394-7, May (1923); C.A., *17*, 3246.

979—BURROUGHS, E. H. Bibliography of Petroleum and Allied Substances in 1919 and 1920. U. S. Bur. of Mines, Bull. 216, 374 pp. (1923); C. A., *17*, 2358.

There are 4532 entries and author and subject indexes.

981—CAMBRAY, A. Bituminous Shales. Chimie et Ind., *Special No.*, 398-410, May (1923); C. A., *17*, 3246.
Description of bituminous shales, their properties and methods of working.

982—CAREY, H. Motor Fuels and Engines of the Future. Oil & Gas Journal, *22*, No. 36, 94 (1923); C. A., *18*, 455.
Carey discusses possibilities of shale oil and alcohol as future substitutes for gasoline.

983—CASTELLI, GAETANO. The San Romedio Mine of Bituminous Schists in the Trentino. Rass. Min. Met. Chim., *59*, 113-5 (1923); C. A., *18*, 1193.
Mountain range of Anaunia dividing Adige and Non valleys composed chiefly of triassic rock, especially dolomites. Near Mollaro these dolomites covered by jurassic and cretaceous rocks and between dolomite and jurassic limestone are strata of bituminous schists. Latter grayish black, usually have schistose fracture (though occasionally conchoidal one) and analyze (ash free) in per cent: H 5-10, C 70-80, O+N 3-16, S 0.9-8. Dry distillation gives (1) 6-30% (av. 15%) of thick, dark oil, d_{20} 0.928, soluble in benzine and CS_2, insoluble in H_2O, rich in S, pyridine bases and unsaturated compounds, strongly antiseptic and valuable for pharmaceutical use; (2) approximately 6% of NH_4OH (4-10 g. NH_3 per liter); and (3) combustible gas (40-60 cu. m. per ton of schist) containing chiefly CH_4, with some CO and C_nH_{2n} compounds. By sulfonating crude oil, an ichthyol product equal to foreign grades obtained.

984—CROZIER, R. H. A New Development in the Treatment of Oil Shales. Min. Mag., *29*, 265-9 (1923); Petr. Times, *10*, 774; C.A., *18*, 1382.
New retort developed in Rangoon, India, described. Believed that large ones of this type may be built to handle 500 or 1000 tons of shale a day at low cost, against only 4.5 tons for large Scottish retort. Tests indicate that complete fractionation of oil may be obtained direct from shale in one continuous operation. Detailed results of tests on Burma shale in retort given.

985—DAY, DAVID T. The Torbanites of Nova Scotia. Oil Eng. and Finance, *3*, 37-42 (1923); C.A., *17*, 1134.
General discussion of shale deposits of this region. Oil obtainable from these shales amounts to 38-60 gals. per ton and $(NH_4)_2SO_4$, 71-80 lbs. per ton. Representative sample gave (in%): oil 17.7, water 3.3, gas 3.0, C 8.4 and ash 67.6. Oil had sp. gr. of 0.852. Distillation tests compared with Mexican crude petroleums.

986—DAY, DAVID T. Oil Shales of the United States. Oil Eng. & Finance *3*, 209-15 (1923); C.A., *17*, 1546.
General survey of industry.

987—DAY, DAVID T. Oil Shale. Oil Eng. & Finance *3*, 383-4 (1923); C. A., *17*, 2047.
Complete extraction of oil in Monterey (Cal.) shale possible in Soxhlet apparatus with CCl_4 as solvent. Product after evaporation of solvent was thick asphaltic material similar to oil obtained from wells drilled into crevices of diatomaceous earth in this region. Pores of diatomaceous earth in this locality coarser than those in most shales and it is suggested that extent to which oils in shales will yield to solvent action depends upon proportional coarseness of absorbing material in shale.

988—DAY, DAVID T. Oil Shale in Esthonia. Oil Eng. & Finance *3*, 505-7 (1923); C.A., *17*, 2189.
Extent of shale deposits, products formed and their uses discussed. Production figures for 1922 given.

989—DAY, J. Retorting Norfolk shale. Petr. Times, *9*, 840 (1923); C. A., *17*, 2778.

991—DEJARNY, MARCEL E. Note on Esthonian Shale Deposits. Chimie et Ind., *Special No.*, 439-42 (May, 1923); C. A., *17*, 3246.
Description of deposits and of experimental distilling plant of Esthonian government.

992—DELOISY, E., and GRAUCE, E. Chimie et Ind., *Special No.*, 434-8 (May, 1923); C. A., *17*, 3245.

Process consists essentially in treating shale in gas producer, using air mixed with portion of fixed gases produced after separating oil, and condensing products of distillation. With somewhat makeshift apparatus over 1000 tons treated from August, 1921, to March, 1922, which shows it was commercially practicable. Yield about 70 l. per m.³ (900 kg.) nearly same as that obtained in Scotch retorts with same shale, and 10-12 kg. of $(NH_4)_2SO_4$ per ton of shale. Function of gas injected with air two-fold: its combustion takes place of primary combustion of fixed C of shale (which caused superficial slagging of shale); it then reacts with fixed C and gasifies it by means of endothermic reaction which prevents slagging. Oil had a density of 0.930, slightly higher than that of oil obtained in Scotch or French retorts, probably due partly to incomplete condensation of lighter distillation products and partly to absence of cracking of distilled oil. Phenol content (about 6%) about same as that of oils obtained in retorts, but it contains 16-17% of unsaturated hydrocarbons as against 8-9% in oils obtained by usual processes. Amount of outside fuel required calculated at about 0.5-0.6% of shale treated; and about 350 m.³, gas having a calorific value of 1100 cal. available per ton of shale.

993—DE MAZARRASA, J. M., and LUNA, J. The Bituminous Minerals of the Province of Santander. Bol. oficial minas metalurgia *1923,* VII, 1; Fuel in Science & Practice *3,* 264; C.A., *18,* 3475.

Santander shales occur in Lias over wide area but contain only 6.7% kerogen. Typical sample contained H_2O 1.15, ash 70.60, volatile 11.30, fixed C 8.30, N 0.16, S 2.00. Distillation of Cianca shale in superheated steam gave 220 l. of gas, 135 g. of liquids and 765 g. of residue per kg. Liquids on distillation gave in per cent: H_2O 62.2; oil 0-85° 0.7, 85-112° 0.7, 112-42° 1.3, 142-70° 1.2, 170-230° 2.3, 230-70° 20.2; residue and loss 11.4. Gas had per cent composition: CO_2 19.0, CO 15.2, O 0.1, H 40.1, N 4.6, hydrocarbons 21.0. Other samples gave similar results. Oil-shale industry of Scotland and elsewhere described.

994—DUMAS, PHILIP. The Bituminous Shale and Boghead Coal (torbanite) Industry. Chimie et Ind., *Special No.,* 387-93 (May, 1923); C. A., *17,* 3246.

Discussion of importance of bituminous shales and of boghead coal as source of oil and of NH_3.

995—ELLS, S. C. Cretaceous shales of Manitoba and Saskatchewan as a possible Source of Crude Petroleum. Can. Dept. Mines, Summary Rept. 1921, No. *586,* 34-41 (1923); C. A., *17,* 2640.

Geological features and origins of these shales described. Analyses of about 30 samples gave from 1 to 10.9 Imperial gals. of crude petroleum per ton. S content of 6 samples of oil averaged 6.5%. Gas yield from 13 representative samples ranged from 410 to 1130 cu. ft. per ton. Two samples of gas gave approximately CH_4 30%, CO_2 28, H_2 8.2, CO 2.1, net calorific value 350 B.t.u. per cu. ft. These shales of little present economic importance as possible source of petroleum or of $(NH_4)_2SO_4$.

Oil Shales of Canada. *Ibid* 41-55.

Summary and review of available information regarding oil shales in various Canadian provinces given. Abundance of petroleum in other localities and production of $(NH_4)_2SO_4$ from other sources than shale make shale industry, at present, unprofitable. Yet oil-shale deposits of Canada remain potentially valuable national asset.

996—EASTERFIELD, T. H., and McCLELLAND, N. New Zealand Mineral Oils. Chem. & Ind., *42,* 936-8 (1923); C. A., *18,* 462.

Attempts to establish mineral oil industry of New Zealand disappointing thus far. Three kinds oil produced, kauri oil by distillation of peat from kauri-gum lands, yield 40 gals. oil per ton peat; oil wells near New Plymouth. Shale from Orepuka in Southland extensive. Shale in beds 4′-5′ thick with rotten roof and substratum of coal of about 12′ thickness. Shale yields 38 gals. oil, 19 pounds $(NH_4)_2SO_4$ per ton together with sufficient gas for heating retorts. Distillation gave burning oil, 25.9%; lubricating oil, 17.6%; paraffin 20.1% and small percentages of other fractions. Shale oil has sulfur content 1.79%.

997—ELWORTHY, R. T. Nova Scotia Torbanites. Oil Eng. & Finance, *3*, 508-10 (1923). *Cf. Ibid 3*, 37-42; C. A., *17*, 2189.
Behavior of kerogen at temperature of 300-550° studied under microscope. Material darkens slightly at 300° and quite noticeably at 400-550°. At 450° violent decrepitation occurs and from 500° to 550° material assumes lighter color about equal to that of ash left in crucible after ignition. When 1.324 g. heated under vacuum of ½ cm. Hg no gas evolved below 380°. Twenty c.c. collected between 380° and 440°. At that temperature oil vapors evolved and condensed. At this point pressure about 30 cm. of Hg. Rapid evolution of gas and oil occurred to 500°. Further heating to 700° gave no more oil or gas. Residue gave on analysis C 35.3%, H 1.4%, and ash 63.2%. Gas was CO_2 2.80, CO 2.65, O 6.35 (av. of 2 samples), unsaturated hydrocarbon 14.37, CH_4 and C_2H_6 44.10 and H 8.84%. Yield per ton 254 U. S. Gal. of oil and 1750 cu. ft. of gas. Ultimate analysis of kerogen showed C 61.27, H 8.58, O (by difference) 11.49, ash 18.74%, ratio C/H 7.14. Solvents had little effect on shale. Flotation tests unsatisfactory.

998—EMERICK, G. VON. Oil Shale and Its Utilization. Gluckauf *59*, 113-20 (1923); C. A., *17*, 1711.
Occurrence, properties and distillation of oil shale reviewed, with description of past methods of gasification.

999—ENGLISH, E. F. The Oil-shale Question. S. African J. Ind., *6*, 308-14 (1923); C. A., *18*, 1193.
Subject treated under following headings: Scotch industry, retort design, American shale, results in U. S., fundamental research, retorting of oil shale, effects of steam, motion of shale, necessary conditions in shale treatment plant and design of retorts for treatment of S. African shale.

1000—FETTKE, CHARLES R. Oil Resources in Coals and Carbonaceous Shales of Pennsylvania. Fourth Series, Penna. Geol. Survey, 119 pp. (1923).
Bulletin gives clear and full discussion of general petroleum situation and outlook for substitutes for petroleum. Carbonaceous shale deposits of Pennsylvania described in detail and results given of large number of experimental laboratory runs for production of oil from such shales and cannel coals. For comparison parallel runs using shales from Western fields included.

1001—FETTKE, CHARLES R. Cannel Coal and Carbonaceous Shale deposits of Pennsylvania. Trans. Am. Inst. Mining Met. Eng., No. 1233-p, 13 pp. (1923); C. A., *17*, 2492.
Important cannel coal and cannel shale deposits of Pennsylvania described as to geological occurrence, microscopic structure and oil-yielding qualities. Laboratory distillation of typical cannel coal (upper Kittanning) gave 50.1 gals. crude oil and 2.8 gals. light oil (recovered from gas) per ton. Results of analytical distillation of crude oils and per cents of saturation in fractions given. Oil distilled from Pennsylvania cannel coals and shales was commercially refined prior to advent of petroleum industry.

1002—FRANKS, A. J., and GODDIER, B. D. Organic Matter of Colorado Oil Shales. Oil Eng. & Finance, *4*, 175-7, 257-61 (1923); C. A., *17*, 3782.
Discussion of theories of origin of oil shales given in attempt to explain nature of kerogen. Work of other investigators reviewed. Kerogen consists of oil-forming and coke-forming constituents. About 8% of former soluble in CS_2. Remainder can be decomposed to series of heavy bitumens from which crude oil obtained by destructive distillation. Coke-forming constituents decompose simultaneously to form fixed C and gas. Primary decomposition occurs not at definite temperature but within range. Primary decomposition resembles cracking and is not depolymerization. Bitumens produced at different temperaturcs not of same composition. Oil-forming part of kerogen is complex mixture.

1003—GAULT, H., MAURICE NICLOUX, G. PFERSCH and R. GUILLEMET. Macro- and Micro-methods of Ultimate Analysis of Bituminous Shales. Mat. grasses *15*, 6461-6 (1923); C. A., *17*, 2778.
In macro-analysis most important factors sampling, temperature and time of combustion. In determination of C accurate results could be obtained only in quartz

tubes at white heat, by burning for 4-5 hrs., and using O for combustion. Much more concordant results obtained for H. In micro-analysis satisfactory results for C readily obtained on 5-10 mg. of shale by burning at dull red heat for about 30-35 min. Larger quantities of sample gave low results. For H, portion of tube containing Pt. boat should be heated to bright redness, and amount taken should contain about 3-5 mg. of organic matter. Quite possibly some of published analyses of bituminous shales and other solid fuels incorrect. Micro-analysis far simpler and more accurate for this kind of work.

1004—GAULT, H., and BOISSELET, L. A Study of the Bituminous Shales of Bourbon-St. Hilaire. Mat. grasses *15*, 6466-70 (1923); C. A., *17*, 2777.
Shale contained H_2O 1.63, ash 66.50, coke (by diff.) 8.87-17.57, volatile 15.30-24.00, C 22.14, H 2.26, N 0.57, total S 3.46, volatile S 2.64, non-volatile S 1.29, $CHCl_3$ soluble bitumen 1.64%. Yield of crude oil maximum at about 500°, decreasing with higher temperatures with increase in yield of gas. Maximum yield of $(NH_4)_2SO_4$ (12.0%) obtained at 800°, with superheated moist air or steam. Distillation should be carried out in two stages: (1) distillation proper to 500°, with or without steam, (2) gasification with superheated air or steam at 800° to obtain NH_3.

1006—HANSGIRG, F., and SANDER, B. The Bituminous Marl of Ismid, Asia Minor. Petroleum Z., *19*, 576-85 (1923); C. A., *17*, 2778.
Geological and geographical description of bituminous deposits in this region given. Experimental retort described by which bituminous and asphalt content of various layers determined. Shale gave on distillation about 10% of gas composed of CO_2 48, unsaturated hydrocarbons 5, H_2 40, CH_4 2 and air 5%. It has heat value of 5000 cal. Oil solidified at 45° because of its high content of paraffin. Asphalt of m. p. 105° obtained from dephlegmator products. This is bright, hard, asphalt, of sp. gr. 0.84, viscosity of 50° of 3.4, flash 80° and is analogous to best natural asphalt.

1007—HENDERSON, J. Geology of the Nevis Valley. Otago. N. Zealand J. Sci. Tech., *6*, 123-8 (1923); C. A., *18*, 211.
Lignite seams, oil shales and Au gravels notes. Three analyses of coal and 7 of oil shale given.

1008—HENTZE, E. The Technological Valuation of Brown Coals and Oil Shales As Raw Materials for the Production of Crude Tar. Braunkohle, *22*, 433-7 (1923); C. A., *18*, 318.
Laboratory apparatus described (*cf.* Ger. Pat. 370,720) consisting of vertical retort of 15.75 liters capacity. For low temperature coking an Fe retort suitable, for high temperatures refractory material impervious to gas necessary. Chamber heated by surrounding refractory double jacket of inverted U shape containing small-sized heat-resistant C, which in turn insulated by thick jacket of chamotte powder. Double jacket of C serves for passage of electric heating current, which enters at bottom, passes to other side through outer jacket and back through inner jacket. With this apparatus characteristics and industrial value of anthracite, bituminous coal, brown coal, peat, oil shale, wood, etc., for high and low temperature coking determined. I number of shale tar useless in valuating quality, since thiophene often present and renders determination inaccurate. Tars containing low per cent S such as those from brown coal, oil shales, etc., should be utilized for production of benzine and lubricating oils, tars with medium S for fuel oils and tars with high per cent S for pharmaceutical preparations.

1009—JAKOWSKY, J. J. Uses of Water in the Oil Shale Industry. Bur. Mines Tech. Paper, 324 (1923); pp. 1-50.
Water needed in shale oil plant for fire protection, power plant, mining, retorting, condensing, $(NH_4)_2SO_4$ manufacture, oil refining, paraffin wax purification and for domestic uses of community. This last may be as large (30-60 gals. per capita) as all rest together. In mining consumption of water proportional to tonnage of shale, in retorting and refining proportional to gallonage of oil produced. American petroleum refineries use from 25 to 43 gals. water per gallon crude oil handled but 90% of this recovered for reuse. Discussion of

sources of water supply and of possibilities of partial reuse given.

1011—JONES, J. C. Suggestive Evidence on the Origin of Petroleum and Oil Shale. Oil Eng. & Finance, *3*, 443-3, 452 (1923); C. A., *17*, 2097.
Examination of deposits in Nevada indicate oil shales originate as fresh-water muds containing high per cent of spores, algae and other non-woody material partially decomposed by bacterial action, but not sufficiently to raise appreciably relative proportion of fats, through removal of other plant substances. Origin of petroleum muds, sands and calcareous muds deposited in saline waters and containing considerable per cent of organic matter, largely algal in origin, but may in special instances consist chiefly of other plant and animal remains so thoroughly decomposed through bacterial action that fats form relatively high per cent of organic matter remaining.

1012—KARRICK, L. C. Distilling Oil Shales. Petr. Times, *10*, 367, Sept. 18 (1923).
Curves given showing changes in production of crude shale oil caused by different rates (temperatures) of distillation.

1013—KARRICK, L. C. Effects of Temperature and Time of Reaction in Distilling Oil Shales on the Yields and Properties of the Crude Oils. Bur. Mines, Repts. Investigations No. 2456, 8 pp. (1923); C. A., *17*, 1885.
Varying rate of distillation of oils from oil shale changes quality of oil by modifying temperature at which decomposition takes place, and by influencing extent to which reactions of decomposition take place. Oils formed during slow distillation formed at lower temperatures than oils formed during rapid distillation. Proper designs of commercial retorts should make possible proper conditions of distillation so that oils of desired quality can be produced. It is concluded, although data incomplete, that per cent of S and N compounds in crude oil decrease as rate of distillation and temperature maintained decreased.

1014—KARRICK, L. C., and PARRY, V. F. A Melting-point Bridge for Petroleum Shale oils and Shale oil Distillates. Ind. Eng. Chem., *15*, 600-2 (1923); C. A., *17*, 2496.
Line of oil to be tested drawn by means of stylus along heat conducting rod, temperature of each end of which different and accurately measured. Point determined where oil passes from solid to liquid state and melting point calculated therefrom by formula:
$(T_h - T_c)D/100 - T_c =$ melting point
where T_h is temperature of rod at hot end, T_c temperature at cold end, and D distance in cm. from cold end to break in oil line.

1015—LOHEST, M., and RASSENFOSSE, A. The conversion of Shales to Phyllites. Ann. Soc. Geol. Belgique, *46*, 37-42 (1923); C. A., *18*, 1453.
Analyses show water of combination in argillaceous material decreases with increasing degree of metamorphism, likewise with increasing age of deposits. Schists from Cambrian to Carboniferous, respectively, gave following content of combined water: 3.25, 5.84, 7.24, 7.92, 7.86; younger shales, 8.47, 9.85; kaoline, 13.90.

1016—McKEE, R. H. Gasoline Ten Years Hence. Can. Chem. Met., *7*, 4-6 (1923); C. A., *17*, 871.
Survey of outlook for future supplies with discussion of possibilities of oil shales.

1017—McKEE, R. H., and GOODWIN, R. T. Organic Matter in Oil Shales. Ind. Eng. Chem., *15*, 343-9 (1923); C. A., *17*, 1711.
Carbon-hydrogen ration in Colo. shale 6.7 : 1 and oil distilled therefrom by vacuum distillation 5.5 : 1. Thus lower yield of oil from given shale which is completely carbonized, higher may be per cent of saturates in oil. If shale is heated slowly, yield of oil less, but its per cent of saturated compounds increased. Nature of oil produced largely dependent upon method of retorting. Different shales have different decomposition temperatures and reaction both endothermic and exothermic. Curves give this difference in thermal decomposition temperatures. Action of several solvents on shale determined. Not commercially possible to extract oil from shale with solvents for oil not present as such in shale. Formation of oil through

an "intermediate product" that has been isolated. Formation as follows: kerogen, "Intermediate product", shale oil. In contrast with formation of unsaturates from petroleum by cracking, vacuum distillation of shale yields highly unsaturated "intermediate product" which largely converted into saturated compounds by distillation under atmospheric pressure. For more complete report on examination of organic matter in oil shale by same authors *Cf.* Colo. School of Mines Quart., *18,* No. 1, Sup. A., (1923).

1018—MORESSEE, G. A Remarkable Property of Argillaceous Material. Ann. Soc. Geol. Belgique, *46,* 173-83 (1923); C. A., *18,* 1453.

If standard solution of some basic aniline dye is added to water containing argillaceous material (clay, shale, slate, schist, phyllite), coloring matter absorbed or "fixed" by material, supernatant liquid remaining uncolored until certain number of cc. of standard solution have been added. This number is capacity of fixation and is constant for certain degree of metamorphism, decreasing from clay to phyllite. Experiments with solution of $CuSO_4$ and NH_4OH show mineral salts may also be fixed in this way. When shale passes into slate or phyllite some of fixed mineral salts are freed, to be taken into solution by circulating waters. Upon encountering soluble substance such as limestone, mineral deposit would result at contact. Believed that presence of impurities explanation of this property of fixation. Fixation number may possibly be utilized in determining geological horizon of schists or related rock.

1019—MURRAY, A. L. The Sanitation of Oil Shale Camps. Bur. Mines Tech. Paper 324 (1923), pp. 51-57.

Gives summary of laws governing use and pollution of waters, unfortunate effect of spent shale dumps on domestic water supply, proper constructions for temporary and permanent outhouses, requirements of water per capita, factors on which proper choice of camp or town site depends.

1021—PASLEY, J. F. W. Norfolk Shales and the Fusion Retort. Petr. Times, *9,* 790 (1923).

Criticism of previous article. Advantages of fusion retort set forth.

1022—PLAUSON, HERMANN. Recovery of Oils from Bituminous Shales, Peat, Coal, Etc. Petr. Times, *10,* 87-9 (1923); C. A., *17,* 3246.

Process consists in mechanically driving off substance to be recovered by means of superheated steam or inert gas moving through mass of coal, etc., at rate of about 300-600 meters per second. Thus organic constituents of bituminous shale can be recovered in nearly theoretical quantity yield if steam superheated to about 350° and under 8 atmospheres of pressure is passed through layers of shale 30-50 cm. thick. Temperature on other side of layer not over 105-120°. Oils thus obtained without decomposition and yield up to 50% low boiling point hydrocarbons (80-200°). Same yield at lower temperature possible if 1-3% of solvent like benzene, gasoline, etc., be used.

1023—REEVES, J. R. Economic Study of the New Albany Shale. Bur. Mines, Rept. Investigations No. *2466,* 19 pp. (1923); C. A., *17,* 2498.

Development of shale industry depends on several factors such as location in respect to market, climatic conditions, transportation facilities, labor supply, water supply. Utilization of oil shale comparable to utilization of low-grade ore. Mining and preparation for retort important factors. Shale in this district averages about 100 ft. thick, yields 6-16 gals. per ton of oil of sp. gr. 0.931 (60° F.), 41.5% b. below 275°; unsaturation of this fraction 39.2%.

1024—REEVES, J. R. Results of Assays of the New Albany Oil Shale. Bur. Mines, Rept. of Investigations No. *2492* (1923); C. A., *18,* 463.

Samples used for assay were fresh unweathered specimens collected mostly from quarries. Apparatus and methods used for assaying described in Bull. No. 210, U. S. Bur. of Mines. Results of following determinations tabulated for number of samples—oil yield, water yield, sp. gr. of crude oil, distillation of crude, unsaturation of "tops" (fraction b. up to 275°) carbon residue from atmospheric distillation, yield of scrubber naphtha, per cent N. Oil yield varies

from 4.8 to 15.7 gals. per ton with average 10.3 gal. Sp. gr. 0.924-0.955 average 0.943. "Tops" 38.8-52.9, average 44.1%. Unsaturation "tops," 39.0-45.0, average 42.1%. C residue 4.95-7.67, average 6.3%, N 0.107-0.777, av. 0.381, or equal to 35.89 lbs. $(NH_4)_2SO_4$ per ton.

1025—RITTER, E. A. Distillation of Oil Shale at Puertollano, Spain. Eng. Mining J. Press, *115*, 326-7 (1923); C. A., *17*, 1712.

Shale mined at a depth of 300 ft. It is crushed to 1-2½ in. and distilled in retorts with capacity of 4 tons in 24 hrs. 6-ft. vein gives average yield of 30 gals. per ton. Scottish (Oakbank) type of retort used; consists of upper part of iron construction 11½ ft. high and lower portion of brick 14½ ft. high. $(NH_4)_2SO_4$ produced sold as fertilizer. Other products kerosene, lubricating oil, phenols and paraffin oil.

1026—SCHEITHAUER, W. Shale Oils and Tars and Their Products. 2nd ed. revised and enlarged by H. B. Stocks, London: Scott, Greenwood and Son. 283 pp. Reviewed in Chem. Trade J., *72*, 705 (1923); C. A., *17*, 2955.

1027—SINGER, LEOPOLD. Developments in the Field of Mineral Oil Analysis and the Mineral Oil Industry as well as Oil Shale Investigations in the Year 1920-1921. Petroleum Z., *19*, 571, 724, 803, 835, 882, 969, 1001, 1038, 1069, 1110, 1170, 1208, 1243, 1278 (1923); C. A., *18*, 897.

1028—SMITH, J. T. Oil-Shale Companies should Manufacture Carbon Black. Railroad Red Book, *40*, 441 (1923); C. A., *17*, 2047.

Recent tests show that after oil has been distilled shale residue yields C black or substance similar to it, which can be recovered by flotation methods in which shale oil is flotation medium.

1029—STEWART, ROBERT J. G., and TRENCHARD, JOHN. The Destructive Distillation of Oil Shale. Quart. Colo. School Mines, *18*, No. 3, 6-32 (1923); C. A., *18*, 1048.

Two steps in the distillation of oil shale: (1) conversion of kerogen into bitumen and (2) decomposition of bitumen into gas, oil vapors and C; both of these steps or stages probably occur at same time. Temperature lag between inside and outside of piece of shale through ¼-in. mesh, 200°. Products greatly influenced by retorting conditions. On first heating shale heavy oils given off instead of light oils as in case of petroleum. This heavy product may be decomposed into lighter products by additional heat. Shale used in retorting tests came from Elko, Nev., and was claimed to be typical of shales found in Western U. S. Laboratory retort 8 in. in diameter and 22½ in. long and electrically heated used. 2-kg. charge used. Several runs made with different rates of increasing temperature in order to determine this effect. Final temperature applied in each case 900° F. For similar rates of temperature rise there is an earlier and more rapid production with smaller size of shale. With large size and similar rise in temperature there is slower decline in production rate. Rapid heating to maximum temperature increases yield and produces more oil on an economic basis. Greater bulk of oil can be extracted below 600° F. Yield increases with increase in size of shale and also with early high temperature. Per cent saturation decreases with rapid heating and with size of shale. Vacuum materially decreases per cent saturation, but increases yield. Sp. gr. decreases with increased yield.

1030—WINCHESTER, DEAN E. Oil Shale of the Rocky Mountain Region. U. S. Geol. Bull. 729 (1923).

This 200-page bulletin contains probably the most complete discussion of American Western oil shales from the geological standpoint. Distribution, geology, oil yield, stratigraphic relations and fossils present are all gone into in much detail. Numerous maps and photographs are included. Bibliography on oil shale given.

1031—LANDA, STAN. Concerning Bituminous "Cyprisschiefer" in Bohemia. Petroleum Z., *19*, 501 (1923); C. A., *17*, 2640.

Tests made on 49 samples of shale. Average moisture content 25-30%. On heating, combustible gas and black residue formed. Samples dried at 140° gave 67-96% ash. Those from the region of

Falkenau have lowest ash content. Samples from northern part, southwest of Falkenau, and western part gave following tests, resp.: ash 67.1, 74.4, 77.4; combustible matter 32.9, 25.6, 22.1; N 0.42, 0.28, 0.25; S —, —, 0.1%. From the 3rd sample following results obtained: heat of combustion 957 cal.; coking test, liquid constituents 20.8%, residue 79.2%. Residue gave on elementary analysis 1.7% C and 0.2% H. Distillation oil yield 4, water 8, residue 86, gas and loss 2%. 100 g. of the shale gave 5.8 liters of gas of 2600 cal. heat value. The oil is a brown fluid and solidifies at 16°.

1032—STRUNNIKOV, M. F. Some Methods of Analysis of Oil Shales and Sapropelites. Nepht. Slantz. Khoz., *4* (2) 276; J. Inst. Petroleum Tech., *9*, 224A (1923); C. A., *17*, 3782.

Hygroscopic and general moisture determined in desiccator or in drying oven at 90° with powdered sample. Shale perceptibly oxidized at 100-105°, but at 90° this is much less. During drying shale loses water and CO_2 and absorbs O from air. Volatile matter determined by Muck's method with 0.5 g. samples. Platinum crucible must be 4-5 cm. high. N content determined by methods of Kjeldahl and Dumas. S determined by Eschka method, with 0.5 g. sample in case volatile matter large. Definite relation observed between sp. gr. of shales from same deposit and their volatile content. Sp. gr. determined by Chatelier-Kandlo apparatus water, turpentine or gasoline being used as liquid. All methods applicable to sapropelites, but moisture more quickly determined in evacuated desiccator than in drying oven, both methods giving same results.

1033—SWINNERTON, A. A. Preliminary Report on the Investigation of Oil Shales. Can. Dept. Mines, Summary Rept. 1921, No. *586*, 239-49 (1923); C. A., *17*, 2640.

Total of 101 samples of oil shale from all parts of Canada subjected to distillation in electrically heated furnace specially constructed to insure uniform heating of all parts of charge, and control of various factors involved. Results shown in 12 tables. Most of oil came over at about 400° (*cf.* McKee & Lyder, Abs. 836). Yield of oil per ton ranged from 4 to 32 Imperial gals., gas 400 to 1500 cu. ft. and $(NH_4)_2SO_4$ 1 to 40 lbs.

1034—SWINNERTON, A. A. Report on the Investigation of Oil Shales (of Canada). Summary report of Mines Branch of Investigations in 1921. Can. Dept. Mines, pp. 239-252, Bull. 590 (1923).

Methods useful for testing samples of oil shale described. Found for oil shales that optimum decomposition temperature in close neighborhood of 400° C. Details of tests of New Brunswick and Pasquia Hills District given. New Brunswick samples indicated that yields of about 20 Imperial gallons oil per ton shale may be expected in commercial operations, while for samples from Pasquia Hills District of Saskatchewan and Manitoba about 10 gallons oil per ton shale expected.

1035—THWAITES, R. E. The Production of Liquid Fuels from Oil Shale and Coal in Australia. Inst. Science and Industry, Australia, Bull. *24*, 62 pp. (1923); C. A., *17*, 3601.

General survey of oil resources of world as well as of Australia. In latter continent no crude oil produced. Refinery being constructed at Melbourne to take 200,000 tons of Persian crude per year to supply about 35% of Australian needs. Known oil shale deposits of small areas and production of shale oils and tar spirits inconsiderable. Coal resources offer most hopeful solution of motor fuel problem but they await development of low-temperature processes to make oil yields possible.

1036—TREVOR, T. G. Oil-yielding Rocks in the Union of South Africa. Oil Eng. & Finance, *4*, 253-6, 277-80, 301-5 (1923); Petroleum World, *20*, 358-60; S. African J. Ind., *6*, 285-307; C. A., *17*, 3854.

Geological and geographical distribution of oil-bearing rocks are described. Oil-yielding material of Ermelo district indistinguishable from torbanite of Scotland and yields 22-98 gals. per ton of oil, while other deposits resemble usual shales or cannel coals. Each of deposits described in detail.

1037—TUPHOLME, CH. H. S. Carbonizing Coal at Low Temperatures in the Fusion Retort. Chem. Met. Eng., *29*, 752-5 (1923).

Describes "Fusion Retort" and process which has been used on cannel coal, torbanite, coal dust and shale. Retort consists of horizontal rotating steel cylinder 2½′ to 4′ diameter by 25′ to 100′ long. Rotates 5 to 7 RPM. New idea in this retort is breakers to give chipping or hammering action to prevent growth of scale on retort. These breakers consist of number ⅜″ iron rods mounted alternately at right angles to each other along shaft made up of two irons. Length of rods about ⅔ diameter of retort. Breakers not supported but float in retort by falling during rotation of retort stirring material and chipping off material which starts to form along walls. Retort heated externally, products of combustion pass in opposite direction to material in retort.

In second type double tube used. Material passes along inner tube and back in annular space between tubes. Results of runs on these products given.

1038—VALGIS, V. K., and MAGURD, M. The Utilization of Nitrogen contained in Russian Shales. Nepht. Slantz Khorj, *4*, (1) 88 (1923); Fuel *2*, 349; C. A., *18*, 463.

Investigation of amount of N in Russian shales, with experiments on Weimarn and Volga shales to determine distribution of N in products of their dry distillation and conditions giving maximum per cent NH_3. Weimarn shales low in N (0.2%) and badly distributed in products, H_2O solution containing only 5.5% of total. Volga shale had average of 0.4% N, of which 18.9% passed into H_2O solution on dry distillation. Like Scottish shales, steam distillation had favorable influence on yield of NH_3 from Russian shales.

1039—WALLACE, G. W. Extraction of Oil from Shale. Chem. Age (London), *9*, 625-7 (1923); C. A., *18*, 1048.

At Santa Maria, Calif., 20-ton and 40-ton units operated over period of months. Plans, specifications and cost estimates given for 1000-ton daily capacity plant of 40-ton type generators. Estimated cost $0.73 per ton. This cost includes mining, crushing, transportation, charging, generator operation, discharging and spent shale disposal, pumps, lights, dehydration, maintenance, labor, supervision and overhead. Oil content of shale about 42 gals. per ton and of this 89% being recovered. This plant began operating their 20-ton unit in June, 1922.

1040—WEEKS, W. G. The Origin of Oil Shales. Oil Eng. & Finance, *3*, 643-3 (1923); C. A., *17*, 2696.

Criticism of Jones' theory, Abs. 1011.

1041—WINCHESTER, D. E. Oil Shales of Colorado and Indiana Compared. Railroad Red Book, *40*, 823-8 (1923); C. A., *17*, 3782.

Known data concerning shales found in these two regions tend to show that Colorado shales far surpass Indiana shales because of their much greater thickness and richness and their greater availability for manufacture of shale oil and $(NH_4)_2SO_4$ at low cost.

1042—ALDERSON, V. C. Oil Shale Bibliography, 1923. Quart. Colo. School Mines, *19*, No. 1; Railroad Red Book, *41*, 11-16 (1924); Mountain State Mineral Age, pp. 35-38, Dec. (1923); C. A., *18*, 897.

1043—ALDERSON, V. C. Oil Shale Industry—A Résumé for 1923. Quart. Colo. School Mines, *19*, No. 1; Railroad Red Book, *41*, 7-10; and *42*, 341-8; Mining J. (London), *144*, 47, 74 and 91 (1924); Petr. Times, *11*, 385-387 (1924); Combustion, *11*, 286-290 (1924); C. A., *18*, 897 and 1193.

A review.

1044—ALDERSON, V. C. The Oil Shale Industry—A Review of its Technology and Trade. South African Mining & Eng. J., *36*, 661 (1924).

1045—ALDERSON, V. C. Retorting of Oil Shale. Mining Cong. J., June (1924), p. 283; Railroad Red Book, *41*, 725-6 (1924); Petr. Times, *11*, 918 (1924).

Most serious problem confronting oil shale industry retorting. All shales not alike. Scottish methods not applicable to American shales. U. S. has greatest deposits in world.

1046—ALDERSON, V. C. Oil Shale in U. S. Railroad Red Book, *41,* 53-5 (1924); Mining Cong. J., July (1924), p. 331; Mountain States Mineral Age, April (1924), p. 19; Petr. Times, *11* (1924); C. A., *18,* 2423.

1047—ALDERSON, V. C. Oil Shale Throughout the World. Combustion, *11,* 56-9 (1924); C. A., *18,* 2959.
Review. Deposits of oil shale occur in U. S., Brazil, Australia, Canada, and many European countries. Discusses oil-producing possibilities from shale, and retorting methods.

1048—ALDERSON, V. C. Oil Shale in Foreign Countries. Railroad Red Book, *41,* 597-8 (1924); Mining Cong. J., Aug. (1924), p. 370; Petr. Times, *11,* 14 (1924); C. A., *18,* 2423.

1049—ALDERSON, V. C. The Trumble Oil Shale Cycle Distillation Plant. Quart., Colo. School Mines, *19,* July, Cf. Ibid Oct. (1924); Railroad Red Book, *41,* 789-93 (1924); Petr. Times, *11,* 327 (1924); Mountain States Mineral Age, July (1924), pp. 15-17; Am. Eng., Russian, Nov. (1924), p. 19; Am. Mining Cong. J., Sept. (1924), p. 450; Mining J. (London), *146* (1924), p. 700; Chem. Age (N. Y.), *32,* 789-93 (1924); C. A., *18,* 3472.
Trumble retorting process continuous cyclic process. Crushed shale fed into top of vertical retort and treated therein with vapors from cracking still. Vapors from retort pass to dephlegmator, heavy cut from which passes to cracking stills, three in number. Light cut from dephlegmator passes to agitator where pyridine, etc., removed as acid sludge. Pyridine recovered from sludge by distillation. Cracking still consists of two concentric tubes heated by superheated steam in inner tube, oil passing through space between tubes. Steam and vapors from retort pass through turbine before reaching dephlegmator, whereby electricity for general power uses generated.

1051—ANON. The Shale Deposits of Sweden. Petr. Times, *11,* 211 (1924).
Tests prove that high grade crude oil produced from Swedish shale. Costs of production make possible entering competition.

1052—ANON. The Scottish Oil Shale Industry. Oil News (London), Mar. (1924), p. 230; Petr. Times, *11,* p. 316 (1924).
Deputation to Board of Trade—calling attention to status of shale oil industry in Scotland.

1053—ANON. Oil from South African Shale. Petr. Times, *11,* 163 (1924).
Lamplough-Harper processes used in experimental work on these shales. Yield of NH_3 stated to be sufficient to pay retorting costs and leave surplus.

1054—ANON. The Oil Shales of Esthonia. Petr. Times, *11,* 883-4 (1924).
Esthonia shales among richest in world. Production has increased at substantial rate since 1918. Future very bright, since country does not have coal fields. Produce large yields of crude oil. One ton Esthonian crude oil gives following refined products: Motor spirit, 60 gals.; illuminating oil, 20 gals.; lubricating oil and fuel, 90 gals.

1055—ANON. The Oil Shale Deposits of East Amherst, Burma. Petr. Times, *12,* 564 (1924).
These deposits only oil shale of economic importance discovered in Indian empire.

1056—ANON. The Oil Shales of Somerset. Petr. Times, *11,* 185 (1924).
Important discoveries of oil shale in Somerset.

1057—ANON. The Oil Deposits of South Africa. Petr. Times, *11,* 232 (1924); Cf. Ibid., *11,* 161.
Hutchins says "fusion" retort best for treating South African shale. Ermelo proposition profitable.

1058—ANON. Oil Shale Experiment Station. Petr. Times, *11,* 937 (1924).
American Government officials have now given recognition to needs of oil shale industry.

1059—ANON. The Oil Productiveness of Esthonian Shale. Petr. Times, *11,* 443 (1924).

Report of experimental work carried out with Esthonian shales.

1061—ANON. Shale Oil Produced Commercially. Petr. Times, *12,* 986 (1924).
Catlin Producing Co. exploiting oil shale commercially at Elko, Nevada. Description of process given, also products of industry.

1062—ANON. Exploiting the Manchurian Oil Shales. Petr. Times, *11,* 903 (1924).
Exploitation will probably commence in near future. Proposed to erect plant for distilling shale with subsidiary plants for recovering NH_3. Estimated to cost 5,000,000 yen.

1063—ANON. The Fractional Distillation of Oils from Oil Shale. Petr. Times, *11,* 619 (1924).
Describes Crozier apparatus for treatment of oil shale. British patent recently granted for apparatus.

1064—ANON. Oil Shale Developments in Sweden. Petr. Times, *11,* 618 (1924).
Huge deposits in Sweden of oil shale of very useful quality, low S. On Lake Vauern near mountains of Kunnekulle and Billinden.

1065—ANON. The Fuel Oil of the Future. Petr. Times, *11,* 24 (1924).
All oil produced from oil shale distillation undoubtedly inferior in quality to average petroleums. Economically important to produce refined product equal to well petroleum products. Refining restricted to low boiling fractions such as gasoline and illuminating oil.

1066—ANON. Crozier Retort at Wembley. Petr. Times, *12,* 231 (1924).
Exhibited by Mineral Oils Extraction, Ltd. Capital costs per ton capacity and operating cost low. Heat introduced by means of series of flues which traverse retort diagonally. Method of withdrawing vapors from retort eliminates possibility of cracking and produces oil yielding readily to refining. Shale fed condensor at top of retort.

1067—ANON. Esthonian Oil-Shale Industry. Petr. Times, *11,* 121-2 (1924); C. A., *18,* 897.
Extracts from the Esthonian Government report give production and consumption statistics. Consumption of shale as fuel for all kinds of boilers gradually increasing in Esthonia.

1068—ANON. Deposits of Bituminous Schists in France. Rass. min. met. chim., *60,* 98-9 (1924); C. A., *18,* 2671.
Geologic and chemical features of seven chief basins described. *Autunois:* This contains most extensive and richest strata. From 1 ton of schist is obtained an average of 90 liters (approximately 23 gals.) of crude oil, yielding in liters on fractional distillation benzine 5, kerosene 20, heavy oil 10, tar 35, also 3 kg. paraffin. By treatment of ammoniacal H_2O, approximately 12 kg. of $(NH_4)_2SO_4$ obtained. *Aumance:* Strata of this basin second in extent and richness. One ton of schist yields 70-80 liters of oil and 8 kg. of $(NH_4)_2SO_4$. *Manosque:* Schists contain 24% volatile, 8% H_2O and 4-6% S. Yield per ton, 160 liters of crude oil from principal deposit, giving on fractional distillation in per cent: benzine 5, kerosene 40, lubricating oil 40 and paraffin 10. *Frejus:* Quality of schist varies greatly, yield on distillation being 12-20%. *Faymoreau:* Relatively unimportant. *Vagnas:* Yield of oil, 13-14%. *Vendes:* Yield of oil, 3-8%. Total estimated easily accessible reserve of basins, approximately 50,000,000 tons of bituminous schists or shale, over half of which is in the Autunois basin.

1069—BAILEY, EDWIN M. The Refining of Oil Shale. Address before Empire Mining and Met. Cong (London), June (1924). J. Inst. Petr. Tech., *10,* 527-59 (1924); Petro. Times, *12,* 147 and 191 (1924); C. A., *18,* 3474.
Scottish shale retorting and shale oil refining practice described in detail. Distribution of cost of refining of shale oil in Scotland approximately as follows: mining, 54%; retorting, 25%; $(NH_4)_2SO_4$ manufacturing, 12%; refining of crude oil, 9%. General principles underlying refining operations are: (1) Separation of various oils by distillation; (2) their purification by chemical treatment; (3) separation of paraffin by artificial cooling and filtration with subsequent purification of paraffin.

1070—BERTRAND, L., HARDEL & GUISELIN. Madagascar and the Petroleum Industry. Pt. III. The Bituminous Sandstones of Madagascar. Chimie et Ind., *11*, 1003-1027 (1924).

Geological knowledge of deposits of bituminous sands and sandstones of Madagascar summarized and region described. Salient facts regarding climate and transportation given. Possible methods of exploitation and treatment include dry distillation and heating by steam as well as extraction with solvents. Bitumen very soluble in gasoline, petroleum and carbon bisulfide. Insoluble residue includes part of carbon. Constants and properties of oils and chemical studies of petroliferous sandstones included.

1071—BIRD, B. M., and MESSMORE, H. E. The Float- and Sink-Test for Fine Coal. Bur. Mines, Rept. of Investigations, No. 2586, 4 pp. (1924); C. A., *18*, 1739.

Laboratory means of effecting accurate separation according to sp. gr. of coal, bone and shale described. Organic solutions and solutions of mineral salts used. To meet all requirements solution must have minute adjustment from 1.25 to 1.8 sp. gr. Liquid employed must be inert towards coal and its impurities. Apparatus, procedure and precautions in application of test outlined. Results equally accurate on coarse and fine coal and no limit to fineness of coal that may be successfully treated by this method.

1072—BLACKBURN, C. O. Oil Shale Kerogen by the Fractionation of the Primary Bitumen in High Vacuum and by Organic Extractions. Colo. School Mines Quart., *19*, 9-46 (1924); C. A., *18* (1901).

Distillation of oil shale kerogen, in partial vacuum, provides truer bitumen or primary decomposition product. Such distillation reduces the initial decomposition temperature of kerogen and eliminates excess of O, absence of which tends to reduce the amount of cracking. Shale used from Elko, Nev., deposit as used by Catlin Shale Products Co. Proximate analysis shows: moisture, 6.23%; volatile, 12.27%; fixed C, 24.20%; ash, 57.30%; N, 0.43%; theoretical $(NH_4)_2SO_4$, lbs. per ton, 40.5; oil yield, 32.52 gals. per ton; S, 4.10%. This shale classified as non-asphaltic pyrobitumen. Retorting under reduced pressure was carried out in 6 by 10 in. brass retort with charge of 3374 g. Retorting began at 22 mm. of Hg, but pressure went up as gases, oil vapors and water evolved. Average values for crude retortings: gals. per ton, 40; gals. H_2O per ton, 10.04; cu. ft. gas per ton, 1563; retorting time, 6.22 hrs.; $d_{15.5}$ of oil (dehydrated), 0.878. First drop of oil at pressure of 217 mm. Hg. at 190° and first drop of extra heavy bitumen appeared at 273° at pressure of 305 mm. of Hg. H_2O-insoluble gases appear at 350° and are probably of the ethylene series. Primary bitumen produced under reduced pressure separated into various hydrocarbons by fractionation in high vacuum. Seven cuts were produced by this method. Heptocosane was highest member of paraffin series in high-vacuum fractions. Cracking of this product would account for formation of all lower members of paraffin series. Montan wax was extracted directly from shale by means of $CHCl_3$. Evidence obtained seems to indicate that oil-forming constituents in Elko, Nev., shale kerogen occur as polymerized products of montan wax, which, upon thermal decomposition, depolymerize and form primary bitumen-montan wax; then secondary products, or true oils, formed as result of cracking process.

1073—CLARK, K. A. Bituminous Sands of Northern Alberta (Canada). Report Science Ind. Research Council of Alberta for 1923, pp. 59-72 (1924).

Describes experimental plant by which five tons asphalt separated from bituminous sand (17% bitumen, 83% sand). Separating accomplished by treating with dilute (about 1½%) hot solution of silicate of soda and floating of separated bitumen (70% bitumen, 8% sand, 22% water). Process one of much promise for this type of bituminous sands. Asphalt (bitumen) obtained as above used in treating sticky clay dirt road by mixing with upper three inches of old road material and gave serviceable type of prairie rural road.

1074—CARACRISTI, V. Z. Heat Treatment of Oil Shale. Combus-

tion, *10,* 336-40 (1924); C. A., *18,* 2244.
Illustrated description of apparatus developed by Caracristi and Piron for low-temperature carbonization of coal, which can be applied to retorting oil shale to obtain gasoline.

1075—CASTELLI, GAETANO. The Deposit of Bituminous Ichthyolite Schists of Giffoni Valle Piana. Rass. Min. met. chim., *61,* 68-71 (1924); C. A., *18,* 3712.
Geology, physical and chemical characteristics and present state of development of ichthyolite shales of Giffoni (Salerno) described. Utilizable bituminous material analyzed in per cent: H_2O, 0.18-34; volatile, 13.81-21.59; ash, 49.13-62.67; C, 15.40-36.87; total S, 1.33-4.00; coke, 78.07-86.00. Dry distillation yielded 7-9% oil and 3.5-3.8 m.³ of gas per quintal of schist, having the average per cent composition: CO_2, 26.0; O, 1.2; CO, 11.2; H, 5.2; saturated hydrocarbons, 49.8; unsaturated hydrocarbons, 0.4; N, 6.2, and H_2S, 0.0082 g. per liter. Small amounts of lignite and bitumen also present in shales. Analyses of lignite and its distillation products given, showing among other data 48.3% volatile, 21.6% fixed C, and a 35% yield of oil and 12 m.³ of gas per quintal on dry distillation.

1076—CYREN, OTTO. Oil Shale in Esthonia and its Use. Svensk. Kem. Tids., *36,* 53-69 (1924); C. A., *18,* 2803.
Shale field in Esthonia covers approximately 30 by 100 kilometers. Layers are remarkably uniform throughout. The strata tilt to the south about 4°. The ash content is also quite uniform. The diagram indicates 8 bituminous-shale layers. These vary from 18 to 100 cm. and add up to 300 cm. The organic matter in these layers ranges from 35 to 51%. The maximum for S is 1.5% in the 50-cm. layer and for all others less than 0.7%. The highest ash content occurs in the 18-cm. layer and comes to 63%. The lowest ash is 30%. The ash components in the order of magnitude are (per cent): SiO_2, 20-42; CO_2, 17-28; CaO, 22-37; Al_2O_3, 5-9; Fe_2O_3, 3-6; $K_2O + Na_2O$, 3-5; MgO, 1-2. The shale is used for gas in Reval and Darpat and yields 300 cu. m. per ton and 3-5% tar. The composition of the gas was as follows (per cent): H, 37.6; CH_4, 25.8; CO, 19; CO_2, 13.3; N, 2.6. In distillation this shale gives a raw oil consisting mostly of unsaturated hydrocarbons, d. 1.01; flash point, 100-120°; viscosity, 5.5; calorific value 9600. It is free from paraffins. The yield, based on organic matter present, ranges from 55% in the 18- and 20-cm. layers to 68% in the 50-cm. layer. The fractional distillation per cents are: up to 200°, 3; 250°, 12; 300°, 35; over 300°, 40; coke, 12; gases, 9. These are maximum figures. The distillation products described are: benzine, motor oil, lubricating oil, pitch, asphalt and ash. The shale ash is being used to produce a cement.

1077—DAY, DAVID T. Oil Shales of Brazil. Oil Engineering & Finance, *5,* 232 (1924); C. A., *18,* 2244.
Oil shales of Brazil appear to be of two kinds. The first are characteristic of the coast regions and are true shales. On distillation they produce 20-40 gals. of crude oil per ton. The oil is of paraffin base. The second kind is a pyrobituminous sandstone probably deposited in the Permian period in the large inland sea which occupied the basin now drained by the Plate River. These shales yield 20-30 gals. of asphalt base crude oil per ton.

1078—DEBEQUE, GEORGE R. What is Wrong with Oil Shale? Chem. Age, *32,* 233-6 (1924); Mining Met., No. 183, 215-19 (1924); Railroad Red Book, *41,* 661-7 (1924); Oil & Gas J., *22,* 82, 94 (1924).
Excellent discussion of those factors which have retarded the expected rapid development of the shale oil industry. These factors are: lack of co-ordination between oil refiner and mining engineer, unexpected flush well petroleum production from the California fields, undue emphasis placed upon retorting processes, lack of reliable information regarding cost of mining, general economic consideration in which income tax is involved and delays in receiving patent titles to oil shale land.

1079—ELLS, S. C. Bituminous Sands of Northern Alberta. Petr. World, *21,* 152 (1924); Can. Mining J., March 28, 298-304 (1924).

1081—FINLEY, W. L., HORNE, J. W., GOULD, D. W., and BAUER, A. D. Assay Report Studies of Ten Typical Oil Shales. Bur. Mines, Rept. of Investigation, No. 2603, 9 pp. (1924); C. A., *18,* 3711.

Co-operative study of oil shales by U. S. Bureau of Mines and State of Colo. Several shales examined by retorting under five different rates, other conditions being kept constant. Shale samples from following sources examined: Grand Valley, Colo.; Scotland; Soldier Summit, Utah; Clay City, Ky.; Turfa from the State of Bahia, Brazil; Elko, Nev.; "mahogany" stratum, DeBeque, Colo.; "Curly Massive," DeBeque, Colo.; black shale, DeBeque, Colo. With one exception, all shales examined yielded more oil at fast rate than at slow rate. At slower rates quality of oils superior to that of oils produced at faster rates insofar as amount of light distillate, percentage of unsaturation, viscosity of vacuum distillation fractions, and C residue of vacuum distillation residuum concerned, although quantity of crude oil less. Volume of gas greater in slow runs, but gas yield holds no relation to oil yields. Australian and Scottish shale oils showed highest saturation of any of oils tested. Oils from Scottish, Nevada and Australian shales similar to crude petroleums of so-called "paraffin base"; Kentucky shale oil rich in asphalt, and Colo. and Utah shale oils tested intermediate. Tendency of shales to fuse when heated does not bear any direct relationship to oil yield. Size of particle, provided sample is thoroughly mixed, has no effect on oil yield. Vapor-phase cracking of shale oil as it is being produced from retort causes lowering of oil yield, and increase in sp. gr., an increase in per cent of light distillate from crude oil, but decrease in amount of distillate from unit quantity of shale, lowering of setting point and increase in C residue. Partly filling assay retort does not affect quantity or quality of oil produced.

1082—FORBES-LESLIE, W. The Oil Shales of Somerset. Chem. & Ind., *43,* 532-9 (1924); C. A., *18,* 3711.

Shale beds discovered in Somerset covering total of about 20 sq. miles. Shales are blue, black and brown and have thickness of 1-25 ft. and over. Somerset shales have average gravity of 2.4; lowest sp. gr. 1.88, highest about 3.0. Moisture content 4 to 5% and S content up to 3%. Total organic volatile matter averages 33%. Analysis of Somerset shale ash exhibits following composition (per cent): SiO_2, 26.56; Al_2O_3, 13.22; Fe_2O_3, 10.26; CaO, 36.83; MgO, 1.10; SO_3, 10.52; alkalies, CO_2 and loss, 1.51. Retorting Somerset shale in vertical retort produces oil 80% saturated, which resists cracking at temperatures of 410-450°. Gravity of crude shale oils varies from 0.933 to 0.940. Following yields obtained from distillation tests on crude Somerset shale oil (per cent): motor spirit, 9.9; kerosene, 11.9; gas oil, 28.2; light lubricating oil, 27.5; heavy lubricating oil, 18.7; wax, residue and loss, 3.8.

1083—FORBES-LESLIE, W. Oil Shales of Somerset. Petr. Times, *11,* 121-2 (1924); C. A., *18,* 897.

Largest shale deposits yet discovered in England located in this area. Entire vertical depth of black and white beds more than 1000 ft. Black beds consist of rich shale divided into 200 mineable seams varying from 2 to 25 ft. in thickness. Estimated that nine billion tons of oil shale available for treatment and three billion tons of limestone. Forty gals. of oil per ton of shale claimed to be fair estimate for yield from this shale

1084—GAVIN, M. J., and KARRICK, L. C. Test Fractional Education of Oil from Oil Shale in Special Retort. Oil & Gas J., *23,* 94-8 (1924); Bur. Mines, Rept. of Investigations, No. 2588, 10 pp.; C. A., *18,* 1901.

Experiments with small rotary retort of 400 g. charge capacity with Utah shale led to following conclusions Theory of fractional eduction not valid Neither theoretical nor experimental evidence to indicate that oil shales produce preponderance of low boiling distillates at low temperatures and of heavier distillates at higher retorting temperatures. For shale used it was found that sp. gr. of crude oil increased steadily toward end of retorting period, as did melting point. Per cent of distillate to 275° from crude oil greatest in first fraction, decreased in second, increased slightly in third, decreased in

fourth, and increased in fifth fraction of crude. Specific gravity of distillates from these fractions increased successively. "Unsaturation" greatest in distillate from second fraction. Last fractions contained greatest amount of paraffin. S content highest in first fraction. N content lowest in first and highest in last fraction. Index number, which is probably a practical measure of relative amounts of finished motor fuels capable of being made from different fractions, highest for first and lowest for fourth fraction.

1086—GAVIN, M. J. Oil Shale—A Historical, Technical and Economic Study. Bur. Mines Bull., No. 210 (1924).

This is a revised edition of the excellent bulletin covered by Abs. 913.

1087—GRIGOROVICH, K. P. Calculation of the Composition of Producer Gas Obtained from Kachpoursky (Syrzan District) and Baltic Bituminous Shales. Rev. metal, *21* (Extraits), 245-8 (1924); C. A., *18*, 2595.

Theoretical investigation into possibility of using these shales, giving calculation of composition of gas, thermal balance under given conditions and comparison with coal. Means must be taken to ensure complete combustion of fixed C by crushing to about 0.5 in. size, increasing blast pressure or introducing steam in blast; all heat losses carefully guarded against.

1088—GAISSER, F. C. A Carbon Obtained from Oil Shale. Brennstoff—Chem., *5*, 254-5 (1924); C. A., *19*, 570.

Coal-like matter prepared from oil shale by treatment under pressure with NaOH and extraction of residue with mineral acids is compared with a gas coal by analyses and tests.

1089—HRADIL, G. Testing Oil Shale. Petroleum Z., *20*, 2017-8 (1924); C. A., *19*, 889.

Quick fuel test for evaluating oil shales consists in heating small fragments of shale in the flame of a spirit lamp. Per cent of oil in sample roughly determined by appearance of flame, evolution of smoke, etc., according to chart given.

1090—KIRKPATRICK, SIDNEY D. Oil Shale Technology in the Making. Chem. Met. Eng., *31*, 688 (1924).

Discusses proposed mining methods and indicates in how few instances open cut methods can be used. Crushing problem varies, depending on type of retort to be used.

1091—KIRKPATRICK, SIDNEY D. American Progress in Retorting Oil Shale. Chem. Met. Eng., *31*, 770 (1924).

American inventors have proposed more than a hundred processes for distilling oil shale. Describes in detail plants of Catlin Shale Products Co. and Index Shale Co.

1092—KIRKPATRICK, SIDNEY D. Persistent Pioneering on Oil Shale Production. Chem. Met. Eng., *31*, 884 (1924).

Describes plant of Monarch Shale Oil Co. Ginet retort used.

1093—KIRKPATRICK, SIDNEY D. What about Oil Shale? Chem. Met. Eng., *31*, 611 (1924).

Developments to date have been in five periods: prospecting for shale, geological survey of deposits, entrance of land speculator, entrance of promoter with a "patented" retort, entrance at present day of technologist with willingness and desire to determine fundamentals of industry.

1094—KIRKPATRICK, SIDNEY D. Economic Problems in Oil Shale Development. Chem. Met. Eng., *31*, 651 (1924).

Shale oil will depend for its market upon well petroleum situation. Well petroleum production characterized by sudden increases and equally sharp recessions, thus bringing periods of overproduction and demoralized market conditions sharply on heels of threatened shortages and high prices. It is certain that large shale oil industry will come shortly and that it will make most progress if built on foundation of technology and sound economics.

1095—LANDA, STAN. The Bituminous Cypris Shales in Bohemia. Petr. Z., *20*, 1707-8 (1924); C. A., *19*, 397.

Analyses of samples of shale, dried at 140°, from the northern, southwestern and western sections, respectively, gave (per cent): ash, 67.1, 74.4, 77.9; combustible matter, 32.9, 25.9, 25.6; N, 0.42, 0.28, 0.52; S, ..., ..., 0.1.

1096—LINKER, SOPHIE. Relation of Peat to Oil Shales. Chem. Age (N.Y.), *32*, 63-4 (1924); C. A., *18* (1901).

Peat and lignite found in many regions of the U. S. but will not be utilized as fuel for many years. Oil shales will be utilized first because so situated that they can be easily mined, distilled and the oil refined. Shale will be utilized when well oil prices reach $3-$4 a bbl. and shale oil can be produced for $2-$2.50 a bbl. In formation of shale believed that mud and sand were laid down in water in which various plants were preserved, more or less, and embedded in the soft muddy deposit. Microscopic examinations substantiated this theory. Shale probably formed under same conditions as peat. Test borings at bottom of deep peat deposits show fine-grained rubber-like layer formed from algae. This known as algae peat or dopperite. So-called kerogen probably originated from humates, plus some bacterial activity. Varieties of shale due to proportion and type of organic and mineral matter, and proportion of humates which were precipitated from humic acids by bacteria.

1098—MAIER, C. G., and DRAPEAU, J. E. Effect of Various Gases on Recovery of Ammonia from Oil Shale. Univ. Utah Bull., No. 14, Eng. Exp. Station, Jan. (1924).

Authors pass various gases through shale (from Soldier Summit, $N_2 = 0.50\%$) being retorted. Analyses gases for ammonia. CO_2—no effect, even slightly lowers yield of NH_3; accelerates NH_3 formation, lowering temperature of maximum yield to 500°-600° from 600°-700°. H_2O—increasing H_2O content gives successive increments to NH_3 content, the recovery at 100% steam being 73.3% of all N_2. Blank value without steam or other gas is 31.6%. At lower concentrations, maximum yield uses from 500°-600° to 800°-900° at 50-60% steam and then falls to 700°-800° for pure steam; with saturated steam best temperature conditions at 700°-800° C. H_2—dry H_2 increases yield from 31.65% to 48.05%; moist H_2 increases yield to 67.95% where there was about 42% steam in gas. This yield as good as that from 100% H_2O vapor. With dry H_2 the nitrogen was distributed as follows: *

Under same conditions unsaturates showed: †

Nitrogenous compounds are very stable, indicated by large amount of N_2 remaining in shale even at 1000° C. In explanation, assume that as greatest yields are over 600° indirect formation of inorganic N_2 compounds as intermediate steps between organic compounds and the NH_3, with metallic bases present, such compounds might be cyanides, nitrides, or cyanamides, stable at high temperatures in strong reducing conditions.

Decrease in yield due to CO_2 comes probably from

$$3\,CO_2 + 2\,NH_3 = N_2 + 3\,H_2O + 3\,CO$$

which would only take place at temperatures high enough to show appreciable dissociation of NH_3 and CO_2.

Calculations show that the NH_3 cannot be due to synthesis (of N and H to form NH_3).

Concludes that effect of H_2 due to

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* N_2 recovered as NH_3..... 48.99%
N_2 in spent shale..... 21.02%
N_2 in oils produced..... 24.90%
Unaccounted for ..... 5.09% (probably as N_2 in gas)

†

Oil by blank—			
300°-600° C.	38.5	38.0	38.3
Oil produced in H_2—			
300°-600° C.	59.5	61.0	60.3 (Thicker than other
Oil produced in H_2O—			solid at room tem-
300°-600° C.	58.0	57.0	57.5 perature)
Bitumen extracted from shales heated to 350°	...	100%	...

formation of inorganic compounds as cyanides, cyanamides or nitrides. Oils produced in H atmosphere are more unsaturated and hence an oxidation is going on, bases present as nitrogenous compounds becoming oxides setting free NH_3. Above 800° C. the decrease of NH_3 probably due to dissociation or oxidation of NH_3 or inorganic compound to N_2.

1099—MAIER, C. G., and ZIMMERLY, S. R. The Chemical Dynamics of the Transformation of the Organic Matter to Bitumen in Oil Shale. Bull. Univ. Utah, Vol. *14*, No. 7, pp. 62-81 (1924).

Experimental work on oil shale from Soldier Summit, Utah, yielding 40 gals. oil per ton. First experiments run in open tubes, heated at certain constant temperatures for various time intervals, residue being extracted with CCl_4. In open tubes all curves reach maximum (per cent bitumen extracted vs. time) and amount of soluble matter decreases. This shows secondary reaction taking place, becoming predominant when first is practically complete. Tests at 250° C. showed very slow change, however, more gas is given off than would come from inorganic constituents. Second series of tests in closed tubes showed a logarithmic curve or $-dc/dt = KC$, dc/dt being rate of decomposition of organic matter and c being concentration of organic matter at time T. K in per cent per hour is

$$9.68 \times 10^{-2} \text{ at } 365° \text{ C.}$$
$$2.07 \times 10^{-2} \text{ at } 325° \text{ C.}$$
$$4.44 \times 10^{-3} \text{ at } 300° \text{ C.}$$
$$7.36 \times 10^{-4} \text{ at } 275° \text{ C.}$$

Hence

$$\log_{10} K = -9.075 \times 10^3 (1/T) + 13.46.$$

The thermal condition of the reaction is developed from Van't Hoff's principle as

$$\log_e K_1/K_2 = Q/R (1/T_2 - 1/T_1)$$

Q being heat absorbed by system. Q is integrated as a constant here and the value from 300° to 325° was found to be 41,500 cal./mol.

Some oil formed at 365° and K consequently does not lie on the curve. Over 365° C. there was excessive oil formed. Under 275° C. the reaction was so slow as to be negligible. No bitumen formed in 90 days at 100° C. Calculated time for 1% conversion at 100° C. was 8.4×10^6 years.

The authors point out that theory of others that bitumen forms at definite temperature is only an approximation, as it is a function of temperature and time of heating. Formation of bitumen is an endothermic process. That the reaction is of first order and consequently that there is no tendency to revert, is strong evidence that bitumen is not the same as kerogen and that oil shales are not shaley material containing absorbed hydrocarbons.

1101—McKINNEY, J. W. Constitution of Kerogen. J. Am. Chem. Soc., *46*, 968-79 (1924); C. A., *18*, 2244. Cf. Abs. 1017.

Kerogen is organic matter in pyrobituminous shale. New Brunswick shale used, containing 19.44 C, 2.18 H, 1.3 N, 1.18% S and which yielded 30.1 gals. oil per short ton. Per cent extracted by various solvents was: EtOH, 1.5; Et_2O, 2.2; CS_2, 2.8; Me_2CO, 2.6; $CHCl_3$, 2.2; CCl_4, 2.6; C_6H_6, 3.2; C_5H_5N, 2.6; AcOH, 6.9. On large scale, Me_2CO used in extracted oil separated into asphaltenes (10%), resins (5%) and hydrocarbons (85%). Oil filtered through Fuller's earth had density of 0.833, (a)D 0.76, and did not react with dilute $KMnO_4$ or Br_2 Aq. Yield was 1.36% of original shale or about 4% of kerogen. This product then separated by distillation and crystallization until 28 compounds thought to belong to paraffin, naphthene and hydronaphthalene series for which d., n, M. observed and calculated and analyses given. These compounds, with exception of two, probably identical with compounds which have been isolated from very varied sources. By action of C_6H_6 in sealed tube at 200°, amount of extract obtainable from pyrobituminous shale more than trebled. As this amounts to 20% of kerogen it should be investigated in same way as Me_2CO extract. Kerogen may be completely removed from shale by HNO_3, though in highly altered condition, products obtained being humins.

1102—MEYER, J. E. Principles of Oil Shale Retorting. Oil & Gas J., *23*, No. 21A, 92-101 (1924); C. A., *19*, 396.

Retorting experiments carried out in

small electrically heated retort indicate that first substance formed from shale is heavy solid or semi-solid bitumen. This substance is formed between 400° and 410°. Petroleum oils formed from shale are result of cracking of this heavy bitumen.

1103—PETROFF, P. The Fischer Retort for Determining the Amount of Primary Tar in Shales, Lignites and Bituminous Coals. Mat. grasses, *16*, 6754-6 (1924); C. A., *18*, 2070.
Description of apparatus and of method of using it, together with some results obtained by Petroff on various French shales, coals and lignites.

1104—POLAK, A. L. S. Oil Shale and Oil-Shale Industry in Esthonia. Oil Eng. & Finance, *5*, 561-5 (1924); C. A., *19*, 396.
Geological description of Esthonian shale deposits given. Average analyses from more than 1500 samples of first-quality Kochtel shale show: organic matter, 45%; ash, 31%; CO_2, 9%; water, 15%. Calorific value of shale varies from 2100 to 3500 cal. Ibid, 618-20. Estimated that cement factories in Esthonia will use 112,000 tons of oil shale in 1924. Third-quality shale pulverized and blown into revolving ring ovens, producing white flame, while ash is incorporated as an essential part into cement.

1105—SAGUI, C. L. Bituminous Shales of Marchigiano. Giorn. chim. ind. applicata, *6*, 331-2 (1924); C. A., *18*, 3583.
Sagui gives geological data, analyses of samples from different localities, and some results of distillation of shales.

1106—SCHEITHAUER, W. Shale Oils and Tars and Their Products. Second ed., revised and enlarged by H. B. Stocks. New York: D. Van Nostrand Co.

1107—SEARS, J. D., and BRADLEY, W. H. Relations of the Wasatch and Green River Formations in Northwestern Colorado and Southern Wyoming (with notes on oil shale in the Green River formation). U. S. Geol. Sur., Prof. Paper 132-F (1924).
Formations described. Authors state that kerogen of oil shale probably formed in fresh water by accumulation of spores, resins, macerated plants and gelatinous algae. Lower grades of shale would contain more extraneous matter, organic material being carried further out in lake before deposition. This particular formation bears out this theory. References given on subject.

1108—SHATWELL, H. G., NASH, ALFRED M., and GRAHAM, J. I. The Somerset Oil Shales. Petr. Times, *12*, 921 (1924).
Detailed study in laboratory of Somerset oil shales. Yields vary from 6 to 11 Imp. gals. per ton. Dry distillation gave larger oil yields than when distilled in presence of steam. Sulfur in oil, 2.85% to 3.44%. Sp. gr. about 0.940. Fractions by distillation about as Scottish shale oil.

1109—STRAIGHT, H. R. Planer Economies. J. Am. Ceram. Soc., *7*, 523-31 (1924); C. A., *18*, 3261.
Planer, for winning clays or shales used in Germany over 30 years ago. Use described.

1111—SWINNERTON, A. A. Treatment of Oil Shale from New Brunswick by the Ryan Oil Digestion Process. Summary Rept., Mines Branch, Dept. Mines, Canada, pp. 210-218 (1924).
Experimental results indicate that gasoline and kerosene fraction obtained is derived largely from digestion oil and that on shales used process is of little value.

1112—SWINNERTON, A. A. The Hartman Oil Shale Retort. Can. Mines Branch Summary of Investigations for 1923, 54-64 (1924).
Discusses two runs on this retort using Albert shale. Obtained yields of 25 to 32 Imp. gals. crude oil per short ton shale. Gas produced but half that needed to heat retort. Oil yield corresponds in quality and quantity to that obtained by ordinary laboratory methods. Patent calls for electrical heating elements in retort and admission of air to shale gas current, neither of which were used in these experimental runs and probably would not be used commercially.

1113—THOMAS, W. H. Petroleum Ash. J. Inst. Petr. Tech., *10,* 216-20 (1924); C. A., *18,* 2241.
Analyses of 27 samples of ash from petroleums, shale oils, etc., from various countries given. Vanadium and nickel occur in most samples. Various possibilities regarding origin of petroleum as indicated by these analyses discussed. Short bibliography appended.

1114—WALLACE, G. W. Status of the Shale Oil Industry. Eng. Mining J. Press, *118,* 290-2 (1924); C. A., *18,* 3111.
A review.

1115—WATERHOUSE, NORMAN. The Shale Oil Industry of New South Wales. Oil Eng. & Finance, *5,* 86-9, 158-60 (1924); C. A., *18,* 1382.
Kerosene shale deposits in New South Wales are in form of lenticular patches about mile in length and width, and found in certain horizons of upper coal measures of Permo-Carboniferous age, thickness of seams varying from 1 inch to 4½ feet. One seam in Joadja valley over 10 feet thick. Tests of shale in this region have given 100 gals. of oil per ton. In Wolgan valley shale ranges from 50 to 75% volatile, giving 100-150 gals. of crude oil per ton. Historical account of attempts to establish a shale oil industry in this section given. Thus far attempts have not been commercially profitable.

1116—WOOD, H. L. California's Part in the Oil Shale Industry. Oil Age, *21,* No. 12, 9-10 (1924); C. A., *19,* 889.
Only two oil shale plants in U. S. in commercial operation: Catlin plant at Elko, Nev., and Continental Shale Products Co. at Casmalia, Cal. Besides producing a high grade crude oil, the latter plant is obtaining valuable filtering medium by pulverizing the spent shale. High grade flotation oil for concentrating gold, etc., ores also obtained.

1117—ALDERSON, VICTOR C. Oil Shale Bibliography. Quart., Colo. School Mines, *20,* p. 16 (1925).
Bibliography for 1924.

1118—BRADLEY, W. H. A Contribution to the Origin of the Green River Formation and Its Oil Shale. Bull. Am. Assoc. Petrol. Geol., *9,* 247-262 (No. 2, March-April) (1925).
The Green River Formation as a whole is of lake origin. It represents deposits of many different lakes from a long series of changes, lakes being fresh at first but gradually changing to saline due to climatic changes which caused lakes to fill and evaporate periodically. Organic ooze composed mostly of plankton organisms is given as responsible for organic matter of shale.

1119—HOMBERGER, A. W., and SHIPMAN, F. M. Distillation of New Albany Oil Shales. Quart. Colo. School Mines, Jan. (1925) (Supplement B).
A study of methods of retorting these shales found in southern Indiana. 1200 grams shale used per charge. Shale retorted (1) under atmospheric pressure, (2) under atmospheric pressure but in presence of steam, (3) under reduced pressure, (4) under atmospheric pressure but oil vapors passed while hot over granular copper. Yield calculated per ton varied between 7 and 12 gals. oil and 10 and 28 lbs. $(NH_4)_2SO_4$. Best yield in presence of steam. Use of copper reduces sulfur content of oil. Oils fractionated and fractions analyzed for N_2, S, iodine number, loss to H_2SO_4, etc.

1120—WALLACE, G. W. Making Shale Oil in California. Chem. Met. Eng., *32,* 237-9 (1924); C. A., *19,* 1194.
A brief description of experimental plant and the 40 ton plant of the N-T-U Co. at Santa Maria, Cal. Developing and perfecting a process utilizing internal combustion for distillation of oil shale. California shale oil is an asphalt base, contains considerable S and is not as amenable to refining processes as the Utah shale oil.

CHAPTER 12

PATENTS

By Ralph H. McKee

As foreign patents are often hard to obtain brief abstracts of these have been included. No abstracts of United States Patents are given as a full copy of any U. S. Patent may be obtained on payment of ten cents to the U. S. Patent Office, Washington, D. C.

1781—British #1291 — DUNDONALD. "Making Tar, Pitch, Gas, etc., from Coals."
Part of the coal, etc., is burned in a closed chamber, the heat evolved distilling tar, etc., from the remainder.

1838—French #9467—SELLIGUE. "Use of Mineral Oils for Lighting."
Treats shale oil distillate with sulfuric acid and alkali and uses the resulting oil alone or mixed with other oils in lamps.

1845—British #10,726 — DuBULSSON. "Furnace, Apparatus, and Processes for the Distillation of Bituminous Substances, and Treating the Products Thereof."
Distills oil shale with superheated steam using an externally heated retort of cone shape with inner cone so as to obtain an extensive heating surface and at the same time a thin layer of shale.

1850—British #13,292—YOUNG. "Treating Bituminous Coals to Obtain Paraffin and Oil Containing Paraffin Therefrom."
Distills cannel coal or torbanite from ordinary gas house retort. Refines with sulfuric acid and caustic soda and separates paraffin from oil.

1858—U. S. #20,026—ALTER and HILL. "Improvement in Revolving Retorts for Distilling Coal, etc."

1858—U. S. #20,587—SARGENT. "Improvement in Retorts for Distilling Oil from Coal."

1858—U. S. #21,805—ATWOOD. "Improvement in Extraction of Volatile Oils, etc., from Coal."

1858—U. S. #22,406—ATWOOD. "Improvement in Manufacture of Pyrogenic Oils."

1858—U. S. #22,407—ATWOOD. "Improvement in Apparatus for Destructive Distillation."

1859—U. S. #22,573—O'HARA. "Improvement in Retorts for Distilling Oils from Coal."

1859—U. S. #22,798—HATCH. "Improvement in Retorts for Distilling Coal-Oil."

1859—U. S. #23,006—ATWOOD. "Improvement in Apparatus for Destructive Distillation."

1859—U. S. #23,337—ATWOOD. "Improvement in Apparatus for Destructive Distillation."

1859—U. S. #23,362—GILLESPIE. "Improvement in Revolving Retorts for Distilling Coal-Oil."

1859—U. S. #23,427—HOLMES. "Improvement in Retorts for Distilling Coal-Oil."

1859—U. S. #24,212—HOLMES. "Improvement in Retorts for Distilling Oil from Coal."

1859—U. S. #24,587—STEWART. "Improvement in Retorts for Distillation of Coal."

1859—U. S. #25,109—GENGEMBRE. "Improvement in Manufacture of Coal-Oils."

1859—U. S. #26,000—SYMMES. "Apparatus for Manufacture of Coal-Oil."

1860—U. S. #26,739—WILLARD. "Improvement in Coal-Oil Retorts."

1860—U. S. #27,542—GENGEMBRE. "Improvement in Apparatus for Distillation of Coal."

1861—U. S. #32,373—KIRCHHÖFFER. "Improvement in Apparatus for Distilling Coal-Oil."

1862—U. S. #34,195—BULLARD. "Improvement in Apparatus for Distilling Coal-Oil."

1864—U. S. #42,772—HOWARTH. "Improvement in Apparatus for Distilling Off Gases and Vapors."

1867 — British #650 — YOUNG and BRASH. "Distilling Bituminous Substances."
Uses a double wall retort, heat applied to outer wall, hydrocarbon vapors (i.e., shale gas) pass upward between the walls and then downward through the shale in the inner vessel, carrying the oils with them.

1871—British #852—FORDRED. "Refining Paraffin and Spermaceti."
Washes softened paraffin with a soap solution to remove dirt and coloring matter. Resulting wax is then bleached.

1873—British #1327 — HENDERSON. "Destructive Distillation of Shale, etc."
The first retort of the type used at present in Scotland. Four vertical retorts set in a single furnace. Operation batch rather than continuous.

1880—British #1578 — YOUNG. "Destructive Distillation of Shale for Obtaining Mineral Oil."
Describes the use of steam in a vertical retort of Scotch type to increase ammonia yield. Preheats air used for burning spent shale and coal fuel.

1881—British #1587—YOUNG. "Manufacture of Mineral Oil and Ammonia, etc."
Drives off oil at low temperature and ammonia at high temperature. Refines oil partly in the vapor phase. Improves chemical treatment by working as a countercurrent series operation.

1881—British #2169—BEILBY. "Distilling Shale, etc."
Uses a retort of which the upper part is iron and lower fireclay. Process essentially continuous. Uses steam to increase ammonia yield.

1881—British #4284—BEILBY. "Apparatus for Distilling Shale, etc."
Mechanical devices for supporting the vertical retort, etc.

1882—British #1377 — YOUNG and BEILBY. "Producing Ammonia from Coal, etc."
Externally heated retort where steam and gas injected at bottom. Process essentially at two stages as determined by temperatures.

1882—British #5084 — YOUNG and BEILBY. "Treatment of Coal and Other Substances for Obtaining Ammonia, etc."
Describes a type of gas producer, with details for ammonia recovery.

1883—British #540 — HENDERSON. "Distilling or Refining Mineral Oils, and Apparatus Therefor."
A series of stills through which shale oil flows continuously, each still giving a single grade of distillate. Method of protecting still bottoms from coke formation discussed. Process is an improvement in fuel economy.

1884—British #9557 — HENDERSON. "Improved Apparatus for Cooling Oil in Order to Congeal Paraffin Dissolved Therein, and Applicable for Cooling Other Liquids for Analogous Purposes."

Cooled brine circulates in a doubled wall vessel and the paraffin which separates on the inner surface is continuously scraped off.

1884—British #11,987—BEILBY. "Improvements in Separating Solid Paraffin from Oils."
Method of chilling to separate paraffin from oil and removal by filtration.

1885—British #15,836—HENDERSON. "Improvements in Apparatus for Distilling Ammonia."
A modification of the ordinary continuous column still.

1885—British #13,014—HENDERSON. "Improvements in Apparatus for Distilling Shale or Other Mineral Oil or Petroleum."
A series of stills for continuous distillation, the final product being carried down to coke.

1886—British #8756—TERVET and ALISON. "Improvements in Treating and Purifying Paraffin Wax and in Apparatus Therefor."
A modification of the paraffin sweating process embracing a repetition of the sweating process.

1887—British #4—TERVET. "Improvements in Apparatus for Treating or Purifying Paraffin Wax."
Improved design of sweating boxes.

1887—British #1291—HENDERSON. "Improvements in Apparatus for Treating or Purifying Paraffin Wax."
Sweating trays so arranged that the paraffin may be supported by water until solidified, the water then run off, and the paraffin then subjected to the sweating process.

1889—British #6726—HENDERSON. "Improvements in and connected with Retorts for the Destructive Distillation of Shale or Other Oil-Yielding Minerals."
Introduces the use of toothed rollers to facilitate removal of spent shale from retort. Gives other minor improvements in retort design.

1891—U. S. #453,386—POTERIE. "Apparatus for Producing Coal-Tar and Coke."

1891—British #11,799—HENDERSON. "Improvements in Treating or Purifying Paraffin Wax, and in Apparatus Therefor."
Sweats at 80° F. on wire cloth trays.

1894—British #8371—BRYSON, JONES and FRASER—"Improvements in or Relating to Retorts for the Distillation of Shale and Other Bituminous Substances, or for the Calcining of Ironstone and Other Substances."
Introduce retorts having a circular or oval cross section and a rotary discharge table at bottom of retorts.

1895—British #7113—BRYSON, JONES and FRASER. "Improvements in or Relation to Retorts for the Distillation of Shale and Other Bituminous Substances, or for the Calcining of Ironstone, Lime, or Other Substances, also Applicable to Gas Producers."
Retort has a tapered or contracted lower end closed by a rotary discharge table and a steam inlet at bottom of retort.

1897—British #4249—BRYSON. "Improvements in or Relating to Retorts for the Distillation of Shale and Other Bituminous Substances, or for the Calcining of Ironstone, Lime or Other Substances, also Applicable to Gas Producers."
In discharging retort one hopper takes the spent shale from one or two retorts and then through the hopper door the spent shale is later removed.

1897—British #13,665—YOUNG and FYFE. "Improvements in and Relating to Retorts for the Destructive Distillation of Shale."
Combines with the retort devices for continuously feeding in the fresh shale and discharging the spent shale.

1899—British #15,238—YOUNG and FYFE. "Improvements in and Relating to Retorts for the Destructive Distillation of Shale."
Detailed improvements on the Young and Beilby retorts.

1901—British #26,647—HENDERSON. "Improvements in and Connected With Retorts for the Destructive

Distillation of Shale or Other Oil-Yielding Minerals."
Describes use of two toothed rollers for the discharge of spent shale from each retort.

1904—U. S. #759,988—HAGUE. "Retort."

1904—U. S. #775,448—HAGUE. "Retort."

1906—U. S. #821,323—WURTZ. "Apparatus for Distilling Coals and Other Hydrocarbonaceous Substances."

1908—U. S. #878,490—AYLSWORTH and DYER. "Apparatus for Distilling Coal."

1910—U. S. #977,992—WURTZ. "Process for the Recovery of the Paraffin Ingredients from Cannel-Coals and Other Similarly Constituted Bituminous Materials Without Change in Their Chemical Composition."

1911—U. S. #985,053—NOAD. "Apparatus for Distilling Shale and Other Bituminous Substances."

1913—U. S. #1,079,093—AYLSWORTH and DYER. "Apparatus for Distilling Liquids and Fusible Solids."

1914—U. S. #1,115,453—SCOTT. "Apparatus for Treating Coals and Other Hydrocarbonaceous Substances."

1915—U. S. #1,115,454—SCOTT. "Process of Treating Coals and Other Hydrocarbonaceous Substances."

1915—U. S. #1,130,001—MacLAURIN. "Manufacture of Various Products from Bituminous Shale."

1915—U. S. #1,143,319—RIGBY. "Utilization of Peat."

1915—U. S. #1,165,889—MACNICOL. "Apparatus for Obtaining Oils, Spirits and Gases from Organic or Other Materials or Substances."

1916—U. S. #1,191,869-70 — BUSSEY. "Method of Extracting Volatiles from Coals, Shales, Lignites, and Similar Materials and for Refining the Same."

1916—U. S. #1,194,033—KNOTTENBELT. "Process of Treating Petroleum and Shale Oils."

1916—U. S. #1,196,470 — ALDAMA. "Separation of Volatile Products from Solid Carbonaceous Material."

1916—U. S. #1,198,069—SCOTT. "Apparatus for Treating Coals and Other Hydrocarbonaceous Substances."

1917—U. S. #1,224,788—REID. "Process of Securing Combustible Fluids from Carbonaceous Solids."

1917—U. S. #1,227,560—HERBER. "Revolvable Retort for Distilling Oil."

1917—U. S. #1,237,094—BRIOLEAU. "Apparatus for Effecting the Destructive Distillation of Carbonaceous Material."

1917—U. S. #1,242,261—STONE. "Distillation of Coal and Other Carbonaceous Materials."

1917—U. S. #1,244,840—DAY. "Extraction of Hydrocarbon Products from Shales and Coals."

1917—British #112,997—HEYL. "Distilling Shale."
The yield of oil obtained is increased by first soaking shale with 10% of its volume of a liquid hydrocarbon.

1917—British #115,452—HEYL. "Coking, etc."
Distillation products of shale are obtained free from sulfur by mixing with the shale before distilling it a sufficient quantity of a solution of Fe salt, ferrous or ferric chloride, sufficient in proportion for the Fe to combine with all the sulfur in the shale.

1917—British #115,573—PIRANI. "Distilling Shale, etc."
Light paraffin oils and other oils for motors are obtained from shale by this process.

1917—British #115,867—HEYL. "Distilling Shale, etc."
Distillation products free from sulfur are obtained from shale by distilling in a rotary still under partial vacuum.

1917—British #118,522—HILLER. "Coking Processes."
A gas suitable for use in containers or motor vehicles which is mainly CH_4 is obtained by distilling shale in a horizontal or vertical retort.

1917—British #119,700—PEARSE. "Destructive Distillation."
Coal, shale and lignite are destructively distilled while passing through zones of different temperatures.

1917—British #124,231—NELSON. "Distilling Coal, Shale, etc."
Distillation takes place at 350°-450° and in the presence of vapors and gases obtained by cracking hydrocarbon oils.

1917—British #128,255—TAPLAY. "Hydrocarbon Oils."
Mineral and tar oils are hydrogenated and cracked by passing the vapors mixed with steam over carbonaceous spent shale. The operation may be effected at the same time as the distillation of the shale so that the shale oil produced is both cracked and hydrogenated.

1917—British #129,349—FORWOOD and TAPLAY. "Purifying Hydrocarbons."
Shale spirit and other oils are treated for the removal of sulfur by washing with a solution of the sulfites of the alkalies or alkaline earths.

1918—German #321,870—ZELLER and GMELIN. "Recovery of Oil from Shale and Other Bituminous Rocks."
By this process it is claimed that the shale oil yield is increased 100% and that the bitumen which escapes from the shale in the form of gas and which has hitherto been impossible to condense is recovered in the form of a high-grade lubricating oil.

1918—British #119,648—REED. "Extracting Oils, Pyridine, etc."
Distillation accomplished by treating shale with vapors obtained by the distillation process and in the presence of acid added or obtained by distillation.

1918—British #121,102—HAMON. "The Artificial Fuel."
Shale is mixed with cellulose material or residues from tar or pitch. A smokeless fuel obtained by coking blocks in the usual way in retorts.

1918—British #123,418—DAY. "Extracting Hydrocarbon Compounds."
Oils and other hydrocarbon products are extracted from shales by treating with the vapors obtained by the distillation process.

1918—British #142,163 — CHRISTOPHER. "Coking, etc."
A retort for the distillation of oil shales with an external heating flue.

1918—U. S. #1,251,954—BERGIUS and BILLWILLER. "Process for Producing Liquid or Soluble Organic Combinations from Hard Coal and the Like."

1918—U. S. #1,269,747—ROGERS. "Distilling Oil Shale in Situ."

1918—U. S. #1,272,377—CATLIN. "Apparatus for the Treatment of Shale or the Like."

1918—U. S. #1,274,033—GRAFFLIN. "Apparatus for Distillation of Coal."

1918—U. S. #1,276,866—BOYLE. "Apparatus for the Extraction of Hydrocarbon Materials."

1918—U. S. #1,276,879—CRANE. "Process for Extracting Hydrocarbon Materials from Shale and Similar Earthy Material."

1918—U. S. #1,280,178—DAY. "Extraction of Hydrocarbon Oil from Shales and Coal."

1918— U. S. #1,280,179—DAY. "Treatment of Hydrocarbon Materials."

1918—U. S. #1,281,320—ERICKSON. "Apparatus for Extracting and Refining Oils."

1918—U. S. #1,283,000—WALLACE. "Apparatus for Distilling Oil from Oil Shale or Similar Material."

1918—U. S. #1,283,723—GALLOUPE. "Retort for Recovering Values from Oil-Bearing Shales and Similar Materials."

1919—Canadian #188,464—REED. "Hydrocarbon Extraction from Shale."

1919—British #129,992—RYAN. "Extracting Bitumen, etc."
In extracting bitumen from shale the shale is digested with heavy oil at a temperature too low to effect destructive distillation.

1919—British #129,996 — WALLACE. "Distilling Shale, etc."
Distillation in a series of externally heated retorts.

1919—British #142,206—MANN. "Cracking Oils, etc.; Destructive Distillation."

1919—British #162,337—DIVER. "Destructive Distillation in Situ."
In the recovery of oils from bitumen and shale by destructive distillation in situ, the heat is supplied from a source located within the strata undergoing treatment.

1919—British #159,246 — GERCKE. "Carbonizing."
In the continuous distillation of coal and shale by contact with steam superheated to about 500°, the fuel is preheated before it enters the distillation chamber or comes into contact with steam.

1919—U. S. #1,297,022—SHREVES. "Oil from Shale."

1919—U. S. #1,305,109—HOOVER. "Apparatus for Retorting Coal, Lignite or Shale."

1919—U. S. #1,309,890 — GODFREY. "Apparatus for Distilling Shale."

1919—U. S. #1,312,266—NAVIN. "Oil from Shale or Sands."

1919—U. S. #1,314,752—OLSEN. "Burning Shale for Use in Concrete or in Refining Sugar or Oil."

1919—U. S. #1,317,318—ROBINSON. "Apparatus for Distilling Bituminous Shales."

1919—U. S. #1,317,514—McCASKELL. "Distilling Oil from Shale."

1919—U. S. #1,323,204—STRAIGHT. "Apparatus for Distilling Oil from Oil-Bearing Shales."

1917—U. S. #1,323,294—LESLEY. "Utilization of Low Grade Carboniferous Material."

1919—U. S. #1,323,681—DAY. "Hydrocarbon Oils from Shales and Coals."

1920—British #143,223 — GUIGNARD-FELIAT. "Destructive Distillation."
Shale is distilled in the presence of steam and under reduced pressure.

1920—British #154,658—BUSSEY. "Coking."
Charge fed in internally-fired retort continuously and the coked product discharged alternately in opposite directions."

1920—British #165,144 — JONES and BURY. "Treating Effluents; Recovery of Coal, etc."
Liquor obtained by scrubbing coal gas with sea water or fresh water containing or having added to it finely divided carbonaceous matter in suspension is subjected to a froth-flotation process to recover the carbonaceous matter.

1920—British #171,213—CANADIAN & AMERICAN FINANCE & TRADING CO. "Distilling Hydrocarbons."
Distillation accomplished by direct contact with hot products of combustion.

1920—British #174,389—CANADIAN & AMERICAN FINANCE & TRADING CO. "Distilling Hydrocarbons."
Vapors are condensed under pressure at or a little below the dew-point.

1920—British #176,847—BROUDER and COSTIGAN. "Distilling."
Volatile substances are recovered by the continuous circulation of hot gas through materials heated in the heating chamber.

1920—U. S. #1,330,014 — STRAIGHT. "Apparatus for Distilling Oil-Bearing Shale."

1920—U. S. #1,327,572—RYAN. "Process for Recovering Bituminous Material from Shale."

1920—U. S. #1,336,264 — TURNER. "Destructive Distillation of Carbonaceous Materials."

1920—U. S. #1,341,517—PERRY. "Apparatus for Distillation of Peat, Coal, Shale and Wood, or Similar Materials."

1920—U. S. #1,343,100 — THURLOW. "Method of Obtaining Motor Fuels and Light Paraffin Oils from Shale; and Benzene, Toluene, and Solvent Naphtha from Coal."

1920—U. S. #1,350,627—TEN BROECK and WESTON. "Rotary Dry-Distilling Apparatus."

1920—U. S. #1,342,741—DAY. "Process for Extracting Oils and Hydrocarbon Material from Shale and Similar Bituminous Rocks."

1920—U. S. #1,357,278—DAY. "Apparatus for Producing Hydrocarbon Oils from Shale."

1920—U. S. #1,358,662 — WALLACE. "Apparatus for Distilling Carbonaceous Materials."

1920—U. S. #1,358,663 — WALLACE. "Process for Carbonizing Carbonaceous Material."

1920—U. S. #1,358,664 — WALLACE. "Process for Distilling Carbonaceous Material."

1920—U. S. #1,361,005 — BRONDER. "Apparatus for Recovering Volatilizable Material from Shale, etc."

1921—British #156,693 — ERDMANN. "Paraffin Wax."
Apparatus for separating paraffin wax from lignite tar, coal tar, shale tar, etc., by treatment with acetone, the tar and acetone being mixed in a closed vessel and passed through a jacketed cooling and crystallizing apparatus and into a closed vessel.

1921—British #171,918 — DOLBEAR. "Treating Oil Shale."
Oil shale is ground to powder, mixed with water to form pulp, a small quantity of an oily liquid added and the mixture aerated.

1921—British #188,686 — PALUSON'S (Parent Co.), LTD. "Extracted Hydrocarbon from Shale or Wood."
Shale or wood, etc., is treated in vacuo with superheated steam or an inert reducing gas or a mixture of these at high temperature to recover hydrocarbons or turpentine and resin oil.

1921—British #189,542 — IRONSIDE. "Distilling Carbonaceous Materials."
In the distillation of carbonaceous material such as shale, coal, etc., the material is mixed with a heated granular substance such as sand, which supplies the necessary heat.

1921 — British #189,977 — CURTIES. "Briquetting Oil Shales."
Briquettes produced from Norfolk and other oil shales. Potassium or sodium nitrate or a mixture of these introduced into powdered shale to purify the shale from sulfur.

1921—British #195,719—SMITH. "Fuel."
Ground or pulverized oil shales are mixed with binding materials such as coal, tar, pitch, etc., and compressed into briquettes.

1921—British #198,705 — PALUSON'S (Parent Co.), LTD. "Distilling Plant."

Oils, bitumens and resins are obtained from shale by distilling materials in a current of steam or inert gas which moves at a high velocity.

1921—Japanese #37,780—KUROKAWA. "Petroleum from Shale and Sands."
Shale or sands containing petroleum are crushed, mixed with a solvent, such as gasoline or crude petroleum, then with liquid having a higher density than the solvent, such as water, and allowed to stand. Petroleum and solvent are collected from the different layers.

1921—U. S. #1,365,822—GALLOUPE. "Vertical Retort for Distilling Oils from Shale."

1921—U. S. #1,371,160—GINET. "Distilling Oil from Shale."

1921—U. S. #1,373,698—ARD. "Distilling Shale in Molten Metal."

1921—U. S. #1,373,699—ARD. "Distilling Shale in Molten Metal."

1921—U. S. #1,373,890—JONES. "Vertical Retort with Superposed Hearths for Distilling Oil from Shale and Sands."

1921—U. S. #1,376,582 — RENDALL. "Method of Distillation."

1921—U. S. #1,378,643—YOUNG. "Retort Adapted for Distilling Shale, Oil-Sand or Coal."

1921—U. S. #1,381,936—SCHIEFFELIN. "Retort for Distilling Oil-Shale or Similar Materials."

1921—U. S. #1,383,205—HEDGES. "Apparatus for Distillation of Oil Shale."

1921—U. S. #1,384,878 — WINGETT. "Furnace for Distillation of Oil Shale or Similar Materials."

1921—U. S. #1,388,718—JENSON. "Superposed Horizontal Retorts for Distillation of Oil from Shale or Sand."

1921—U. S. #1,389,203—LUTZ. "Apparatus for Distilling Coal or Shale."

1921—U. S. #1,391,825 — GARLAND. "Apparatus for Devolatilizing Coal, Wood or Shale."

1921—U. S. #1,395,898—BISHOP. "Condenser for Shale-oil, etc."

1921—U. S. #1,396,173—FENTON. "Distilling Oil from Shale."

1921—U. S. #1,399,267—MAGRI. "Apparatus for Distilling Fuel and Bituminous Rocks."

1922—British #183,823—KERN. "Distilling Shale."
Shale is ground and briquetted and heated in retort to 700°. After bitumen has been driven off, air is passed into retort and heating continued to 1050°. A porous product is formed.

1922—British #184,451—QUINAN. "Dry Distillation."
Distillation takes place in a retort by the passage there through of hot gases.

1922—British #192,040—WHITE. "Carbonizing Coal, etc."
In low temperature carbonization of coal, shale, etc., hot gas is cleaned and preheated before being again circulated through the retort.

1922—British #193,276 — PINTSCH AKT. GES. "Distilling Shale, etc."
In distilling shale by internal heating with hot gas the amount and temperature of the gaseous distilling medium is regulated between the gasifying and distilling chambers by introducing cold gas or air.

1922—British #196,680 — NESFIELD. "Desulfurizing Oils."
Mineral oils are desulfurized by impregnating them with HCl gas and air, washing with NaOH or KOH and filtering by centrifuge to remove sulfur.

1922—British #197,069 — UNITED KINGDOM OIL CO., LTD. "Distilling Shale."
Combined distillation of shale and cracking and hydrogenation of oil vapors.

1922—Canadian #220,517 — PLAUSON. "Treatment of Oil Shale."
Hydrocarbon is extracted from shale by emulsifying with water by a mechanical disintegration at very high speed.

1922—U. S. #1,405,704—AIMS. "Apparatus for Distillation of Shale, Heavy Hydrocarbons or the Like."

1922—U. S. #1,407,017—DUNCAN. "Destructive Distillation of Coal, Shale, Wood or Similar Substances."

1922—U. S. #1,407,018—DUNCAN. "Destructive Distillation of Coal, Shale, Wood or Similar Substances."

1922—U. S. #1,411,237—DAY. Processes for Treating Hydrocarbon Oils."

1922—U. S. #1,413,779 — RANDALL. "Rotary Retort."

1922—U. S. #1,418,970—POOL. "Oil Separator."

1922—U. S. #1,421,228—HEIMBUCHER. "Vertical Retorts for Treating Oil-Bearing Shale."

1922—U. S. #1,423,527 — JOHNS. "Method or Process of Distillation of Material Carrying a Percentage of Volatile Matter."

1922—U. S. #1,423,716—HEDGES. "Distilling Oil-Bearing Shale."

1922—U. S. #1,425,074 — BUCKINGHAM. "Retort Furnace and Condensing Apparatus for Obtaining Oil and Gas from Oil Shales and Oil Sands."

1922—U. S. #1,426,648—JOHNS. "Material Feeding Mechanism."

1922—U. S. #1,428,458—THOMPSON. "Hydrocarbons from Oil Shale."

1922—U. S. #1,428,590—HILLE. "Centrifugal Apparatus for Separating Shale Oils."

1922—U. S. #1,430,452—LEWIS. "Combined Gas Generator and Retort Apparatus for Distilling and Gasifying Coal, Shale, Lignite, Peat or Wood."

1922—U. S. #1,432,275—BUSSEY. "Apparatus for Distilling Volatile Hydrocarbons from Coal, Shale, or Lignite."

1922—U. S. #1,432,101 — DANCKWARDT. "Distilling Oil Shales."

1922—U. S. #1,432,170—FENTON. "Apparatus for Feeding Finely Divided Shale, Oil-sand or Sulfur Ore into Retorts."

1922—U. S. #1,433,051—WELLS. "Distilling Oil from Shale or Other Solid Materials."

1922—U. S. #1,437,292—DEETER. "Apparatus for Distilling Shale, Coal, Wood, or Other Carbonaceous Materials."

1922—U. S. #1,438,421 — ANENIUS. "Horizontal Retort for Distilling Oil from Oil Shale."

1923—British #195,090 — RED RIVER REFINING CO., INC. "Distilling Hydrocarbon Oils."
Distillation carried out under reduced pressures below an absolute pressure of 25 mm. of Hg and preferably below 5 mm. of Hg.

1923—British #210,402—DeLOISY and GRAUCE. "Distilling Solid Materials."
Solid materials distilled by passage of heated current of gas; temperature controlled by addition of water, steam or cold gas.

1923—British #212,053 — STARKEY. "Distilling Shale."
Shale passed through a series of rabble chambers heated exteriorly by gases flowing counter to the direction of passage of shale.

1923 — British #212,770 — FAIRWEATHER. "Distilling Oil Shale."
Shale passes downward through a vertical retort heated externally by hot combustion gases and internally by heating pipes.

1923—British #213,046—STALLI. "Distilling Oil Shale."
Distilled by partial combustion of a charge of material from which distillate is conveyed to air-cooled condensers by the natural draft through the distillation furnace. The temperature is not over 800° F.

1923—British #213,100—PERRY. "Distilling Shale, Peat, Wood or Similar Materials."
Hot gas is passed through a chamber charged with material to be distilled and the hot gases are passed to a by-product recovery plant and thence returned in a closed circuit to distillation chamber.

1923—British #213,946—HEYL. "Desulfurizing Mineral Oils and Oil-Bearing Substances."
Distilled by an electric current while the material is in intimate contact with an aqueous salt solution and a catalyst.

1923—British #216,922—LAMPLOUGH. "Distilling Shale and Cracking Oils."
Vapors are cooled and uncondensed vapors are mixed with condensates obtained at each stage to increase the yield of saturated liquid hydrocarbons.

1923—British #217,041—BOWATER and FUEL RECOVERY SYNDICATE, LTD. "Distilling Shale, etc."
In destructive distillation of carbonaceous fuel or shale the latent heat of the steam is recovered by means of a heat exchanger of the cooler saturator type.

1923 — British #217,174 — HINSELMANN. "Destructive Distillation of Fuels or Oil Shale."
Distilled by passing through heated inert gases or vapors.

1923—British #221,052 — TRUMBLE. "Distilling Shale, Peat, Lignite, Coal, Wood, etc."
Distillation effected in a closed retort under pressure by use of superheated steam at about 800° C.

1923—British #223,652—PELL. "Retort for Distillation of Coal or Shale."
Coal or shale under treatment passes through tubes the distance between the walls of which is small as compared to their cross sectional wall. Tubes mounted in a common heating chamber so as to be free to expand individually or collectively.

1923—Canadian #234,228 — BROWN. "Apparatus for Treating Oil Shales."

1923—U. S. #1,441,380 — SIMPSON. "Vertical Retort Adapted for Distilling Oil Shale."

1923—U. S. #1,441,542 — STRAIGHT. "Treating Oil-bearing Shale."

1923—U. S. #1,445,423—ULKE. "Liquid Hydrocarbons from Peat."

1923—U. S. #1,447,296—DAY. "Apparatus for Extracting and Distilling Hydrocarbons from Oil Shale."

1923—U. S. #1,447,297—DAY. "Process for the Combined Solvent and Destructive Distillation Treatment of Oil Containing Earthy Material."

1923—U. S. #1,449,875—ULKE. "Apparatus for Hydrogenating Carbonaceous Material."

1923—U. S. #1,451,367—MARKO. "Gas from Oil Shale."

1923—U. S. #1,451,575—HOLMES. "Oil-shale Distilling Apparatus."

1923—U. S. #1,453,037—BOWIE and GAVIN. "Apparatus for Treating Oil Shale or Similar Materials."

1923—U. S. #1,458,357—POSTEL. "Apparatus for Extracting Volatile Products from Oil Shale or Similar Materials."

1923—U. S. #1,458,983—KIRBY. "Shale Oil."

1923—U. S. #1,462,023—STRONG. "Retort for Distillation of Oil-Shale."

1923—U. S. #1,465,277—MAYES and HOMRIGHOUS. "Apparatus for Extracting Oil from Shale."

1923—U. S. #1,467,757—DAY. "Hydrocarbon Oil from Shale."

1923—U. S. #1,467,758—DAY. "Cracking Hydrocarbon Oils."

1923—U. S. #1,468,435—ZANDER. "Apparatus for Distilling Oil from Shale."

1923—U. S. #1,469,628—DUNDAS and HOWES. "Distilling Oil Shale."

1923—U. S. #1,471,492—LAMB. "Shale Retort."

1923—U. S. #1,471,088 — BALLARD. "Apparatus for Separating Oil and Gas from Wells."

1923—U. S. #1,473,616 — GARLAND. "Horizontal Cylindrical Retort for Distillation of Shale, Coal, and Other Materials."

1923—U. S. #1,473,722—FOGH. "Recovering Volatilizable Values from Ores and Similar Substances."

1923—U. S. #1,474,357—GERCKE. "Apparatus for Distillation of Bitumen Materials."

1923—U. S. #1,475,901—THOMPSON. "Apparatus for Distilling Hydrocarbon Oils."

1923—U. S. #1,475,028—REILLY. "Apparatus for Separating Oil from Oil-Bearing Sands and Rocks."

1924—Canadian #239,089—DAVIS and WALLACE. "Apparatus for Distilling Oil Shales and Similar Materials."

1924—U. S. #1,480,045—GAVIN. "Retort, Hearth and Rabble Apparatus for Distilling Oil from Shale."

1924—U. S. #1,481,399—WEBERT. "Distillation of Powdered Coal and Other Carbonaceous Materials."

1924—U. S. #1,482,677—DUNTEN. "Retort for Distilling Oil from Shale."

1924—U. S. #1,484,256—FENTON. "Continuous System for Treatment of Coal."

1924—U. S. #1,486,243—HACKSTAFF. "Oil from Shale."

1924—U. S. #1,487,541—COOGAN. "Apparatus and Method of Extracting Petroleum from Petroleum Sand and Shale."

1924—U. S. #1,487,836—BROWN. "Apparatus for Distilling Oil from Shale or Similar Materials."

1924—U. S. #1,489,905—STALMANN. "Vertical Retort for Producing Oil from Shale."

1924—U. S. #1,490,463—GROVES and LAIN. "Vertical Retort for Oil-shale Distillation."

1924—U. S. #1,490,945—SMITH. "Apparatus for Obtaining Oil from Shale."

1924—U. S. #1,490,213—JENSON. "Oil from Shale."

1924—U. S. #1,490,357—WISNER. "Distilling Hydrocarbons from Oil Shale or Similar Material."

1924—U. S. #1,491,290—DAVIS and WALLACE. "Apparatus for Distilling Oil Shales and Similar Materials."

1924—U. S. #1,493,880—JENSON. "Oil Shale Retort."

1924—U. S. #1,494,736—COOPER. "Ammoniacal Gas from Bituminous Shale Deposits."

1924—U. S. #1,496,293—BRONDER. "Apparatus for Destructive Distillation of Oil Shale, Coal, Lignite, etc."

1924—U. S. #1,496,778—HAMPTON. "Fuel Containing Bituminous Shale."

1924—U. S. #1,498,528—ALEXANDER. "Apparatus for Destructive Distillation of Oil-bearing Shale or Similar Materials."

1924—U. S. #1,498,917—HUTCHINS. "Horizontal Rotatable Retort for Distillation of Coal, Shale or Other Materials."

1924—U. S. #1,499,378—LAMPLOUGH and HARPER. "Retort Still Adapted for Treating Shale."

1924—U. S. #1,500,323—JENKINS. "Oil from Shale."

1924—U. S. #1,501,881—BENNETT. "Retort for Distilling Oil from Shales."

1924—U. S. #1,503,093—CATLIN. "Shale Distillation Plant."

1924—U. S. #1,503,234—FRANCIS. "Retort for Shale Distillation."

1924—U. S. #1,504,772—MANNING. "Purifying and Decolorizing Hydrocarbon Oils."

1924—U. S. #1,509,275—WALLACE. "Vertical Retort for Distilling Oil Shale, Coal or Other Bituminous Substances."

1924—U. S. #1,509,667—CATLIN. "Distilling Shale or Other Carbonaceous Materials."

1924—U. S. #1,510,045—DAY. "Method of Firing Retort Furnaces."

1924—U. S. #1,510,655—CLARK. "Destructive Distillation in Situ of Subterranean Deposits of Oil Shale or Similar Materials."

1924—U. S. #1,510,983—DOLBEAR. "Recovering Oil from Shale."

1924—U. S. #1,511,067—RUSSELL. "Extracting Oil from Oil-bearing Strata."

1924—U. S. #1,513,745—DAY. "Mineral Wax from Oil-bearing Shale."

1924—U. S. #1,513,746—DAY. "Fuel Obtained by Extraction of Shale."

1924—U. S. #1,515,103—GAGE. "Apparatus for Distillation of Shale or Other Materials."

1925—U. S. #1,522,985—TAFF. "Retort for Distillation of Oil from Shale."

1925—U. S. #1,523,942—FORWOOD. "Oil from Shale."

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